Making the Case
for Clean Construction

MEXICO CITY

C40 CITIES

BURO HAPPOLD

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CONTENTS

ACKNOWLEDGEMENTS

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ABOUT

C40 is a network of nearly 100 mayors of the world's leading cities who are working to deliver the urgent action needed right now to confront the climate crisis and create a future where everyone, everywhere can thrive. Mayors of C40 cities are committed to using a science-based and people-focused approach to help the world limit global heating to 1.5 degrees Celsius and build healthy, equitable, and resilient communities. Through a Global Green New Deal, mayors are working alongside a broad coalition of representatives from labour, business, the youth climate movement, and civil society to go further and faster than ever before. The current chair of C40 is Eric Garcetti, mayor of Los Angeles, and three-term mayor of New York City Michael R. Bloomberg serves as president of the board. C40's work is made possible by our three strategic funders: Bloomberg Philanthropies, Children's Investment Fund Foundation (CIFF), and Realdania.

https://www.c40.org/

Buro Happold is an international, integrated consultancy of engineers, consultants and advisers, operating in 26 locations worldwide with more than 70 partners and 1,900 employees. For over 40 years Buro Happold has built a world-class reputation for delivering creative, value-led solutions for an ever-challenging world. As a truly inter-connected community of experts, we value human wellbeing and curiosity, embrace mutual responsibility and genuinely care about the impact and legacy of our work. We believe that both society and business must adapt to the undeniable reality of climate change. We understand the urgency with which we must act. For this reason, we have set ambitious climate action goals both for our operations and for projects we work on.

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FOREWORD

Building Back Better should be understood, literally, as tackling the negative impacts of the construction sector on the people and the planet. The opportunity for change has never been so timely. This report is a key milestone in Mexico City's pathway toward a regenerative, circular and resilient built environment. It reflects their climate leadership whilst laying out tangible actions for many others cities to adjust and adopt.

Manuel Olivera

Regional Director for Latin America, C40 Cities

Mexico City is proud to be one of the front-running cities signatory of the C40 Clean Construction Declaration, along with other C40 cities in the Clean Construction Program, taking leading actions to deliver a resilient, resources-efficient and decarbonized built environment in our cities. ´Making the Case for Clean Construction in Mexico City´ will allow us to move even further.

Dr. Marina Robles García

Secretary of the Environment, Government of Mexico City

EXECUTIVE SUMMARY

THE CASE FOR A TRANSITION TO CLEAN CONSTRUCTION

BOLD AND URGENT ACTION IS REQUIRED

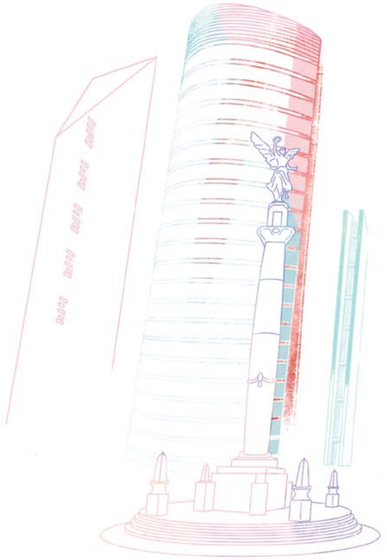
All around the world, cities face a range of challenges. A shortage of affordable housing, longstanding economic, societal and health inequalities, and the urgent need to reduce greenhouse gas emissions and prepare for the impacts of climate change. These challenges are complex and interconnected. Their scale and the urgency with which they must be addressed has been exacerbated, accelerated and further exposed by the COVID-19 pandemic.

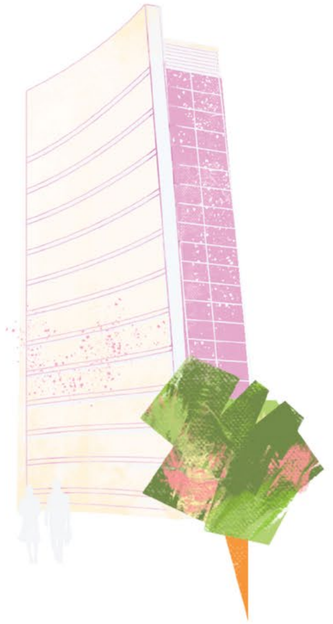
CONSTRUCTION HAS A CRITICAL ROLE TO PLAY

The construction sector has long been instrumental in shaping urban life; delivering critical infrastructure and shelter as well as providing jobs and livelihoods for many. The construction sector however is a significant global polluter, responsible for more than 23% of the world's greenhouse gas emissions.[1] Construction activities also have significant impacts for communities near construction sites and where materials are sourced, contributing to poor air quality, high levels of noise and traffic, and risking the pollution of valuable ecosystems that these communities depend upon.

CITIES MUST SHOW LEADERSHIP

Cities have a critical role to play in showing the vision and leadership needed to facilitate a transition to clean construction - an industry with dramatically reduced greenhouse gas emissions supports the creation of thriving, resilient and healthy communities in our cities, especially for the most vulnerable.





PURPOSE OF THIS REPORT

This report documents the outcomes from research into clean construction in Mexico City, Mexico. It is one of a series that forms part of the C40 Clean Construction Programme. Informed by evidence gathered from literature reviews and interviews with cross-sectoral public and private stakeholders, the report sets out an overview of the construction industry landscape in the city. It presents insights into the current state of construction and clean construction activities already adopted in the city as well as barriers and opportunities to implementing bolder and more ambitious actions. It then proposes a series of recommended clean construction measures the city could adopt, addressing whole life greenhouse gas emissions together with wider social, economic, and environmental issues.

CITY PROFILE AND CONSTRUCTION LANDSCAPE

MEXICO CITY'S LOCAL CLIMATE ACTION STRATEGY

Mexico City has demonstrated significant progress and leadership in its approach to tackling climate change. The city has endorsed multiple C40 commitments, working on research with groups like 100 Resilient Cities, the Ellen MacArthur Foundation and UN WRI Building Efficiency Accelerator. The city has a Local Climate Action Strategy and has made a number of major policy commitments, including to reduce greenhouse gas emissions by 31.4 million tons CO_2e by 2025 [2] and waste to landfill by 70% by 2024. [3]

ACCESS TO SERVICES WITH IMMENSE GROWTH

Mexico City has witnessed immense growth and today is one of the most populous and dense cities in the world. [4] This immense growth has spurred the creation of new buildings and infrastructure across the city, yet many citizens lack access to basic housing and infrastructure needs. This issue is not limited to neighbourhoods identified as informal, [5] though reportedly 22% of the population live in informal settlements. [6]

A FOCUS ON ENERGY REDUCTION AND RENEWABLES

A number of existing actions in Mexico City support the principles of clean construction. The city has invested significant resource in renewable energy transformation and reduction of operational energy demands. [7] In 2016, the city's Environmental Ministry unveiled updated building codes for retrofitting and new construction, providing guidance on energy efficiency performance, incentivised through green premiums on rental prices and tax breaks. [8] Comparatively, there is relatively limited reference to clean construction in policies and programmes at both a national and city level.

TACKLING CONSTRUCTION WASTE AND PROMOTING REUSE

By 2024 the City aims to reduce waste to landfill by 70%, in part by tripling the amount of waste recycled annually. [9] Ambitious targets have been included within recent revisions to legislative requirements such as NADF-007 to drive these outcomes in the construction sector. [10] Across Mexico City there is expertise in refurbishing buildings in response to seismic damage, [11] and high profile examples of adaptive reuse in historic centres, such as Cuitláhuac Park. [12] Though there is limited use in the formal sector, where concrete, steel and brick are the typical construction materials, and sustainability of supply is not guaranteed, timber is used widely in informal and low income communities. As are traditional construction materials such as adobe. However, these are often not constructed in line with local building regulations, and quality can be low.

CHALLENGES FACING MEXICO CITY

Mexico City faces a range of challenges relevant to the built environment. [13] Social equity is a key issue, with many lacking quality housing and access to basic services. A low rate of regulatory compliance across the construction sector is an ongoing challenge, but is being addressed collaboratively with government, local departments and service providers. Significant resource has been invested in improving air quality but pollution is still an issue that affects the health of citizens. Impacts associated with flooding and temperature rises are also anticipated to worsen with the impacts of climate change. The city however has a range of hard and soft powers (see Figure 04) that can be used to drive a transition toward clean construction, which in turn can help address such challenges.

CLEAN CONSTRUCTION RECOMMENDATIONS

Although Mexico City is grappling with challenges linked to air quality, water supply, housing standards, and social equity,[13] the city is also pioneering international efforts towards adaptive reuse of urban spaces and zero waste.[3] Mexico City has a legacy of managing building refurbishment after earthquakes and in particular parts of the city there is evidence of significant capability in the use of bio-based materials like timber, and lower carbon traditional construction methods. This puts the city in a strong position to adopt a variety of ambitious clean construction measures.

While most of the clean construction measures recommended by C40 and Buro Happold would be viable for Mexico City, the research specifically identifies seven priority clean construction measures. These were selected in collaboration with the City based on their potential impact and feasibility in Mexico City, as well as their alignment with the City's priorities. These recommended measures will support Mexico City's carbon reduction commitment but also deliver multiple benefits, whether social or environmental, local or global.

LEARNING FROM MEXICO CITY TO SCALE UP CLEAN CONSTRUCTION IN OTHER CITIES

The research has assisted the municipal government in making the case for a transition to clean construction and has spurred the cross-department engagement required to realise this. It provided the city with a critical opportunity for:

- Raising awareness and understanding of how actions Mexico City is already taking support the principles of clean construction.
- Identification of how existing actions can be built upon to scale clean construction activities across Mexico City, supporting the Local Climate Action Plan 2021-2050 and within the city's powers.
- Identify how clean construction can support the city to address multiple challenges simultaneously, such as poor air quality, high inequality, low quality housing and aging infrastructure.
- Providing a basis for unlocking collaboration for clean construction with the wider built environment sector in Mexico City.

This report is part of a series that will provide a broader insight into how a transition to clean construction might be achieved in a variety of contexts; the specific benefits this will yield in terms of tackling the climate and biodiversity emergencies, and how the wider challenges cities face can be addressed. The recommendations and benefits for Mexico City will be applicable, to varying degrees, to cities elsewhere in the world. It is believed that other cities may be inspired to take action by adapting relevant recommendations to their own specific context.

CITY KEY ACTIONS

Benefits

- Support improvements in economic and labour productivity
- Encourage sustainable production and consumption practices
- Mitigation of risks to physical and mental health
- Foster inclusive, just and transparent governance
- Affordable, high-quality and accessible housing
- Sustainable management of public budgets
- Protection and enhancement of water quality
- Protection and enhancement of air quality
- Support the creation of green jobs and skills
- Reduced noise pollution

Use pilot projects and lessons learnt from INFONAVIT to expand the use of pre-fabricated, off-site and modular construction methods, disseminating the benefits widely

Use building codes and initiatives such as the Sustainable Building Certification Programme to prioritise adaptation and refurbishment of structurally sound buildings, rather than demolition

Establish plans and incentives to promote alternative uses for vacant or underused structures, such as in Mexico City's financial centres where a greater mix of uses could be integrated

Debunk false perceptions to promote wider use of bio-based and lower carbon materials, trialling wider use of traditional materials and through collaboration with manufacturers

Collaborate with institutions such as the Mexican Chamber of Construction Industry to provide clean construction training courses, guidelines and tools

Build on the cities Zero Waste commitment and construction waste management codes (NADF-007) to deliver the physical infrastructure required to facilitate greater reuse and recycling of construction materials

Leverage the significant existing expertise in Mexico City to establish regular maintenance programmes, leading by example through the repair and maintenance of municipal buildings

ABOUT THIS STUDY

C40 Clean Construction Declaration commitments

Through the Clean Construction Declaration, cities lead the way towards clean construction to achieve thriving, resilient and healthy communities, especially for the most vulnerable. Signatories pledge to bring together and inspire stakeholders to take action, and enact policies and regulations where they have the powers to:

- Reduce embodied emissions by at least 50% for all new buildings and major retrofits by 2030, striving for at least 30% by 2025.
- Reduce embodied emissions by at least 50% of all infrastructure projects by 2030, striving for at least 30% by 2025.
- Require zero emission construction machinery in municipal projects from 2025 and zero emission construction sites city-wide by 2030, where available.

ABOUT THE C40 CLEAN CONSTRUCTION PROGRAMME

The C40 Clean Construction Programme supports cities in the transition to resource-efficient, zero-emission construction that will deliver thriving, resilient and healthy communities in our cities, especially for the most vulnerable. The programme examines the means to address the embodied emissions of construction – the emissions associated with the extraction, manufacturing, assembly, transport, maintenance and end-of-life sorting of construction materials. It also explores ways to strengthen climate resilience and to address the health and socio-economic impacts and solutions of the construction industry, by looking at inclusive, safe, resilient and healthy urban spaces, flourishing circular industries and protected local environments that generate better air quality for millions of people around the world.

PURPOSE OF THIS REPORT

This report documents the outcomes from research into Clean Construction in Mexico City. It is one of a series that forms part of the C40 Clean Construction Programme. The outcomes of this deep dive are not a roadmap for the implementation of clean construction in the city. Rather, the report gives an insight to the actions already underway that support clean construction and the current direction of travel. It is not a quantified analysis of greenhouse gas abatement potential but does share insights on those actions that are anticipated to be most impactful based on qualitative research and analysis. It focuses on reducing greenhouse gas emissions as well as unlocking the multiple benefits of climate action.

In turn, the research has assisted Mexico City in making the case for a transition to clean construction. The process has spurred internal and external buy-in for the integration of just and clean construction into the municipal government's climate plans, via cross-departmental and multi-stakeholder engagement. It is intended that this report may inspire many other cities to take action by adapting relevant recommendations to their own specific context.

METHOD

This study uses a mixed-methods approach in collaboration with Mexico City and wider stakeholders in the city's construction and building sector. This approach is summarised in Figure 01 to the right. A detailed methodology can be found in Appendix A and a list of interviewees engaged through the course of the study is provided in Appendix B.

NOTE ON TERMINOLOGY

Many cities target energy retrofit in buildings however we acknowledge that cities across the globe use different terminologies such as retrofit, refurbishment, renovation and sometimes rehabilitation, to refer to structural upgrades, repairs and adaptation of buildings and infrastructure.

In this research, we use the terms 'refurbishment' to refer to structural upgrades, repairs and adaptation of a building. The term 'energy retrofit' refers to actions intended to reduce operational carbon emissions. This distinction is made since many cities presently target 'energy retrofits' and not 'refurbishments'. A best practice 'retrofit' is generally assumed by C40 to involve both energy and materials, aiming at reducing both operational and embodied emissions.

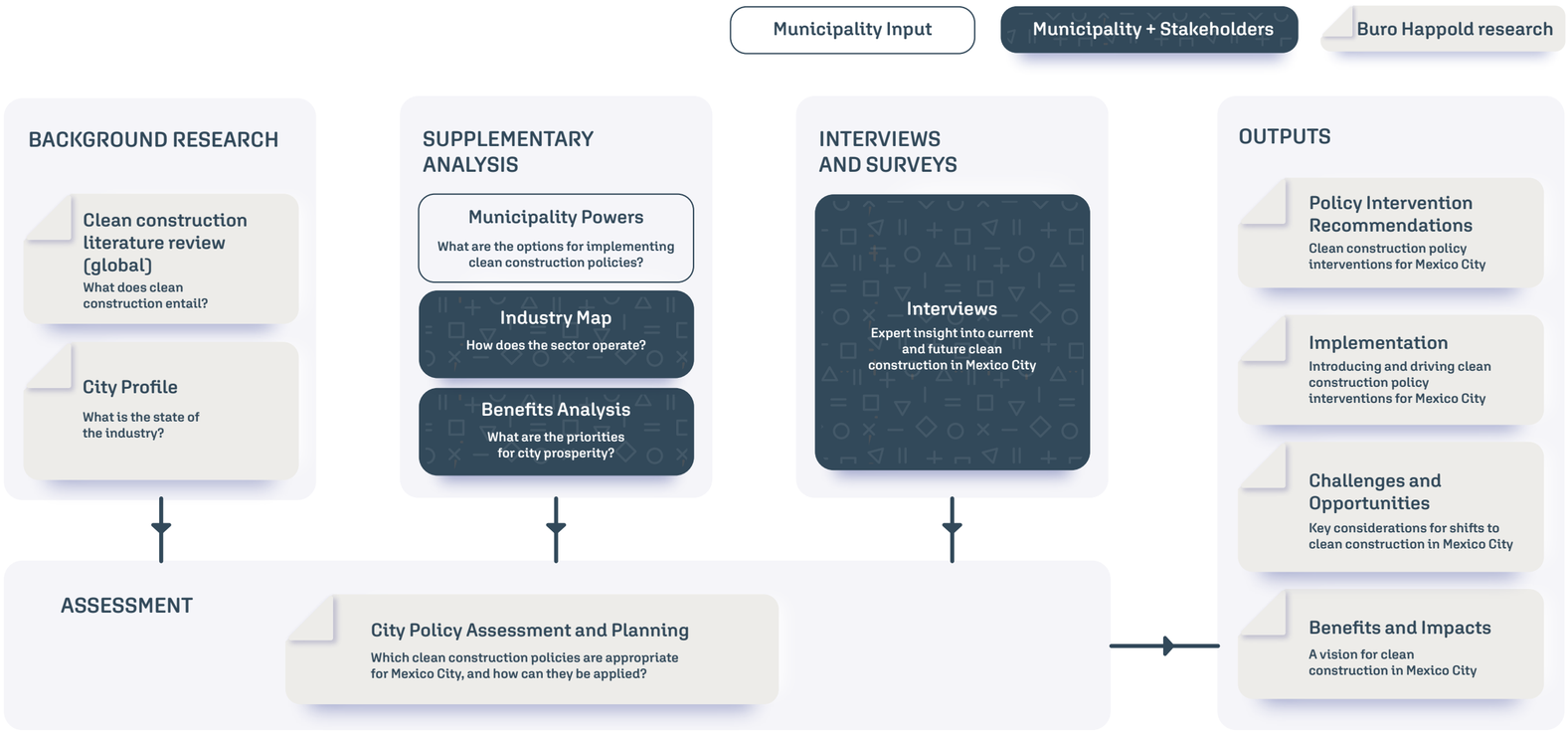


FIGURE 01
Methodology for the C40 Clean Construction series project

1 SETTING THE SCENE

1.1 NEED FOR ACTION

THE WORLD IS HEADING TOWARD A CLIMATE CRISIS AND CITIES HAVE A VITAL ROLE TO PLAY

1.5°C TARGET

In 2016, C40 adopted 1.5°C as the only viable science-based target to secure humanity's long-term future, and the required goal for the climate action plans and strategies of its members. Despite a suite of major world powers declaring new commitments to limit carbon emissions in 2020, this trajectory remains out of reach.[14] A massive recalibration of the global economy is needed for countries to meet this 1.5°C target; or even the goal of the Paris Agreement to limit average temperature changes to 'well below' 2°C by 2100.

CITIES AND THE CLIMATE CRISIS

Consuming more than two-thirds of the world's energy, and responsible for over 70% of global CO_2 emissions, cities have a leading role to play in combatting the climate crisis by taking strong science-based climate action.[15] Cities are also highly exposed to climate risks. C40 research indicates that, without action, 970 cities face extreme heat, 570 risk flooding from sea-level rise and 500 cities face freshwater insecurity.[16] Scientists have found that human-caused climate change has increased the severity of an extreme weather event in 78% of cases studied from the last two decades.[17]

WHY IS URGENT ACTION NEEDED TO CLEAN UP CONSTRUCTION?

CONSTRUCTION SECTOR EMISSIONS

Construction currently contributes more than 23% of the world's greenhouse gas emissions[1] and over 30% of global resource consumption.[18] Many of these emissions are driven by cities' consumption of construction products and services, though they rarely appear in carbon accounting since they are typically produced outside of city boundaries (Scope 3 emissions). By 2050, an additional 2.5 billion people are projected to be living in the world's cities. As urban populations grow, the need for new buildings and infrastructure will intensify.

CITIES AND THE CONSTRUCTION SECTOR

Construction sites can also physically impinge upon urban spaces, having negative impacts on everything from air quality and local traffic flows to noise levels.[19] Reducing emissions from construction to levels where cities meet their 1.5°C targets will also initiate changes in the current supply chain and economic structure of the construction industry, with knock-on impacts on jobs, skills and innovation globally.

COVID-19 RECOVERY

The COVID-19 pandemic and subsequent economic crisis highlights that national governments are seeing infrastructure and construction as one of the main engines of the economic recovery, supported by increased public funding and stimulus packages.[20] While the intention is to create jobs, such rapid expansion of construction without embedding clean construction principles could undermine efforts to abate greenhouse gas emissions and create healthier, just and more resilient communities.

1.2 WHAT IS CLEAN CONSTRUCTION?

Clean construction means a net-zero carbon emissions, resilient and just built environment system that tackles the negative impacts of the construction sector, especially in terms of high greenhouse gas emissions, climate risks, resource depletion, waste generation and socio-economic inequalities. In terms of emissions, clean construction looks at the whole lifecycle of buildings and infrastructure and focuses on reducing embodied carbon levels, which refer to the emissions related to the extraction, manufacturing, assembly, maintenance, retrofit and end-of-life of materials, as well as emissions from construction machinery.

As presented in Figure 02, C40 has established a clean construction hierarchy. The hierarchy follows circular economy and zero waste principles, to promote substantial reductions of virgin material input and generation of emissions and waste. Cities have diverse powers and leverage mechanisms, policy or otherwise, to promote actions in line with the hierarchy. Further detail on how clean construction is defined can be found in Appendix C.

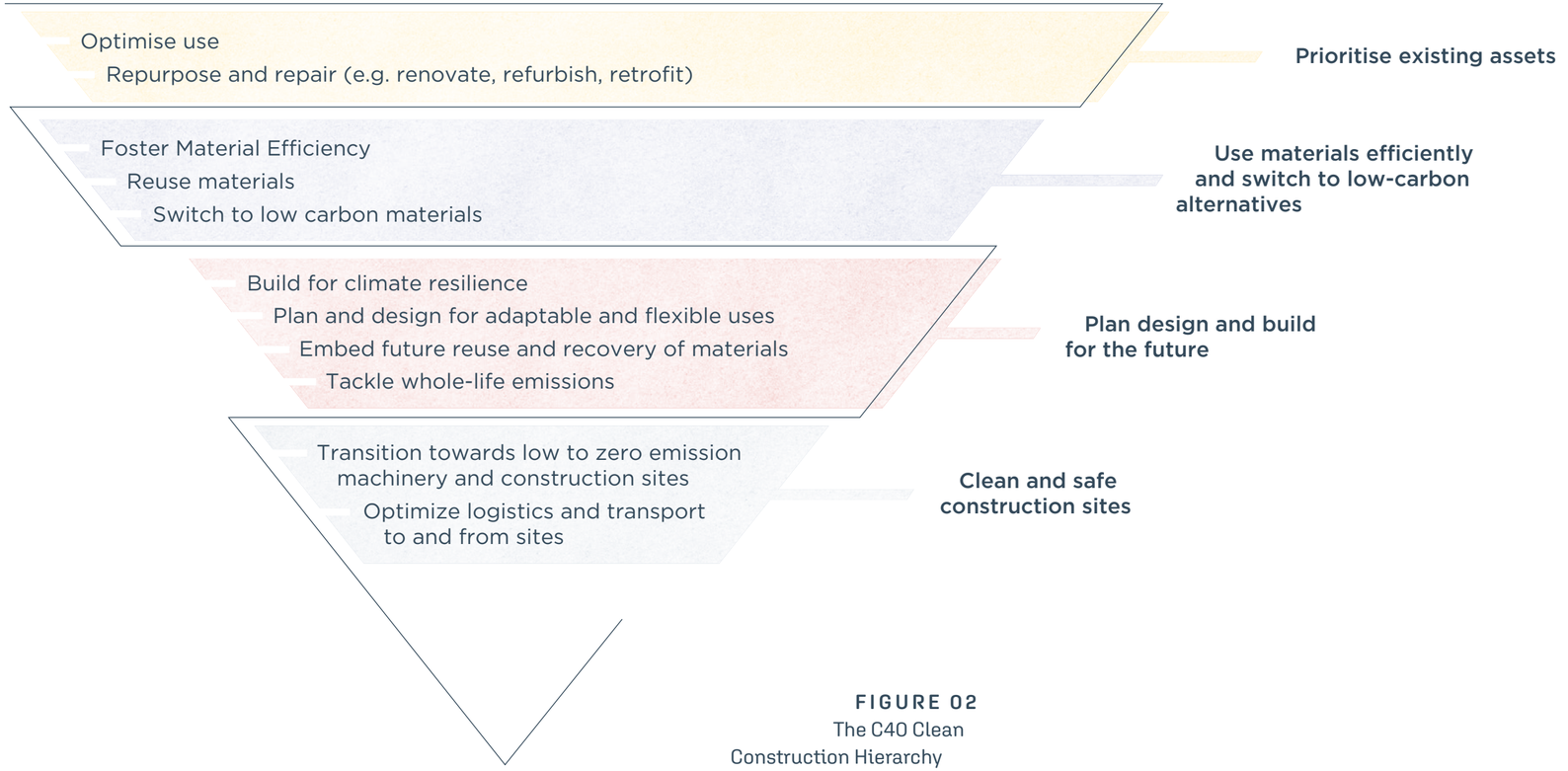


FIGURE 02
The C40 Clean Construction Hierarchy

1.3 WHAT ARE THE BENEFITS OF CLEAN CONSTRUCTION?

Implementing policies that reduce carbon emissions from building and infrastructure construction can contribute to many other city priorities and support or directly bring social and environmental co-benefits, not only locally but also globally (Figure 03). Refer to Appendix C for more details on the overall co-benefits of clean construction, and see Section 2.5 for co-benefits specific to Mexico City.

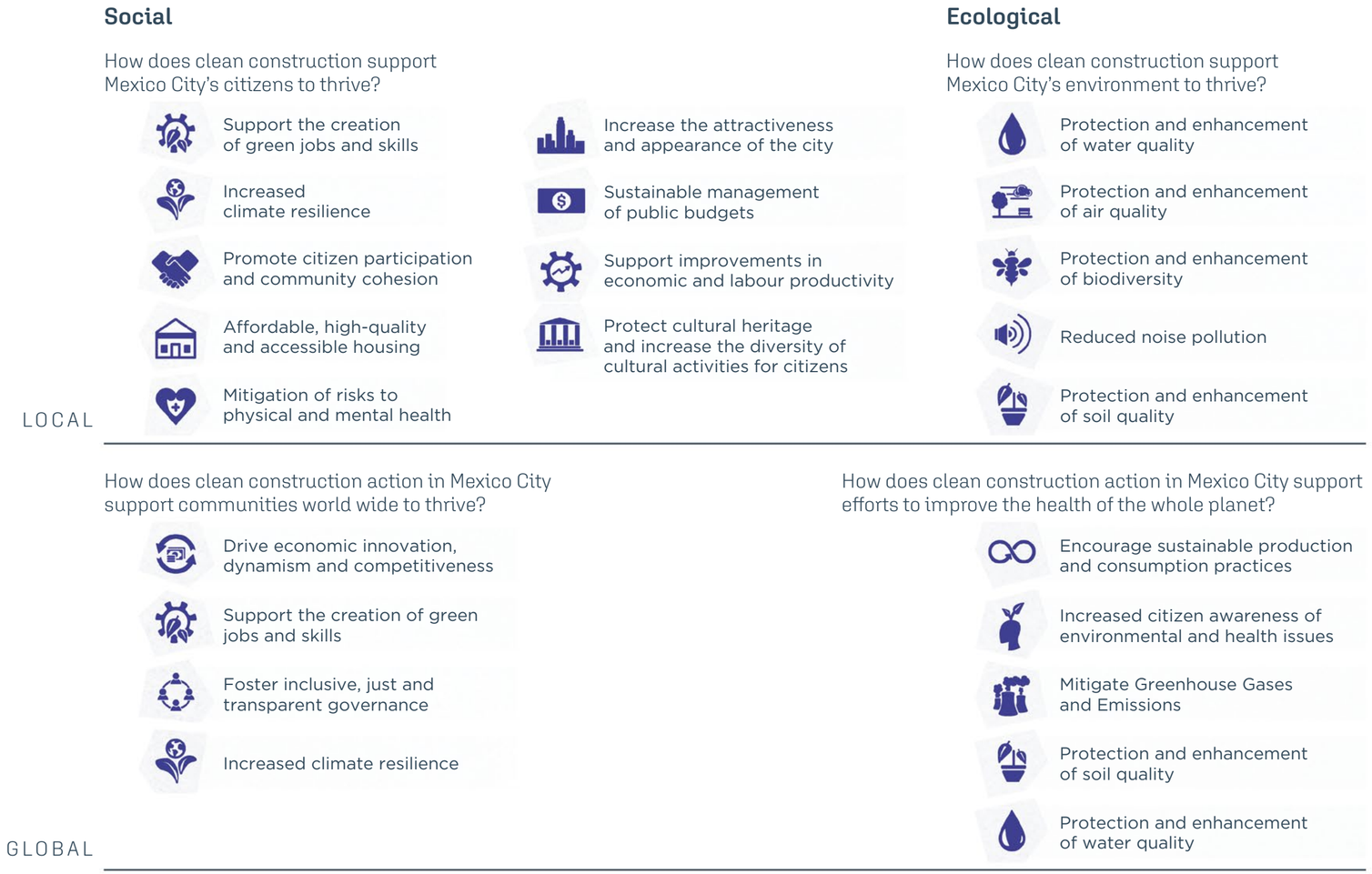


FIGURE 03
Key benefits of clean construction mapped to the four lenses of the City Portrait methodology

2 MEXICO CITY

This section of the report provides a high-level overview of the Mexico City context, its climate action commitments, construction landscape, municipal government powers and priorities, and clean construction actions to date. Further detail can be found in Appendix D.

2.1 MEXICO CITY PROFILE

POPULOUS AND DENSE

Mexico City sits on what was once a freshwater lake, in a basin surrounded by mountains. Today, it is one of the most populous and dense cities in the world.[4] Mexico City is home to 20% of the population of Mexico[4] and is the country's capital.

SIGNIFICANT GENERATOR OF EMPLOYMENT

Key industries in the city are construction, real estate, manufacturing, and tourism.[21] As a whole, a significant portion of financial spending in the country and wider region occurs in Mexico City; it was the largest generator of formal employment of all states and cities in Mexico in 2019, for example.[22] As a result of Mexico City's size and significance to the national economy, one interviewee noted that actions taken in Mexico City are often a catalyst and spur change across other cities nationally.

EMPLOYMENT CONDITIONS AND WEALTH INEQUALITY

The proportion of the population that is economically active, or of working age, is 54% in Mexico City (compared to 57% nationally).[23] There are particularly low rates of employment among young people; in 2019 an estimated 7.1% of 15-24 year olds were unemployed,[24] compared to 3.3% nationally[23]. The COVID-19 pandemic deepened this challenge; 1,117,600 Mexicans lost their jobs in 2020 as part of the economic fallout from coronavirus.[21] Wealth inequality is also significant in Mexico City, in 2018, the city had a Gini coefficient of 0.53, well above the national average of 0.47.[26]

POPULATION AND HOUSING CONDITIONS

RELATIVELY YOUNG POPULATION

The Metropolitan Area of the Valley of Mexico (comprised of 16 delegations of Mexico City and 60 municipalities[27]) is home to approximately 21.8 million people, of which in 2020, 9.2 million lived in official city limits of Mexico City.[28] The population is relatively young, with the largest age group, accounting for 24% of Mexico City's population, between 20 and 34 years.[23] However, this is older than the national population, for which the largest age group (25.8%) is aged between 10 and 19 years.[30] Quality of life and standards of living across Mexico City are mixed.

AFFORDABILITY AND ACCESS TO BASIC SERVICES

Mexico City is the most expensive place to buy residential property in Mexico, with house prices over twice the national average.[31] Yet, 28.4% of the population lives in poverty[13] and it is reported that 22% of Mexico City households live in informal settlements which lack access to key services such as water and sanitation.[32] Basic housing needs are not met throughout the city however and are not limited to neighbourhoods identified as informal;[6] 1.8 million people are reported to lack access to basic housing in the State of Mexico.[33]

CHALLENGES FACING LOW-INCOME COMMUNITIES

Whilst Mexico City does have social housing, developments tend to be in the city's periphery, far from public transport, and lacking in basic services such as water, drainage, and electricity.[13] Services and employment opportunities are concentrated in the city and financial centres, which employ 53% of the population but house only 19%.[5] As a result, commutes – especially for those in low-income occupations – of two to four hours per day are typical.[5] Interviewees suggested that a high number of the city centre developments are developed speculatively and are underutilised. Per capita, residents of Mexico City have 50 sq ft of public and green space, half international standards, with rates even lower in informal settlements and low-income areas.[13]

AIR QUALITY

Over the last two decades the city has improved its air quality considerably, but air pollution remains a problem – regularly exceeding international standards and affecting people's health and wellbeing. Around 6,700 premature deaths are attributed to air pollution every year in Mexico City.[34] Transportation generates approximately 46% of polluting emissions in the city, with particular contributions from diesel vehicles and heavy transportation, including construction machinery and delivery vehicles.[13] In addition, traffic accidents have become the leading cause of death for people between the ages of 5 and 30 and 89% of the roads are not accessible for people with disabilities.[13]

CLIMATE RISKS

Mexico City has a water crisis, intensified by aging infrastructure, climate change, and continued population growth. Per capita water consumption averages 320 l/day, exceeding the UN recommendation of 50-100 l/day, though some low-income areas and informal zones see rates as low as 10 l/day.[32] Losses due to aging and leaky infrastructure and irresponsible use are commonly cited reasons for such high levels of consumption.[32] The cost and quality of water is mixed across Mexico City, disproportionately affecting vulnerable and low income neighbourhoods.[35]

The aquifer in the Valley of Mexico, which Mexico City depends on for most of its supply, has been substantially depleted as a result of over extraction to meet this demand.[32] Moreover, despite 59% the city's land protected as 'Forest Conservation Land',[36] illegal logging and urban sprawl has resulted in much of the forest that surrounded Mexico City and recharged the aquifer being lost.[32] Many peripheral settlements (formal and informal) are only partially covered by the formal water network.[32] As such, access to water services is not equitable and the informal water supply is characterised by illegal pipe connections or 'pipas' (trucks transporting potable water on-demand to marginalised or otherwise inaccessible areas).[32]

Around 5.6 million people in the city (approximately 60% of the Mexico City population) are vulnerable to climate change.[37] Climate change is expected to lead to increased flooding, higher temperatures and more frequent and intense heatwaves.[13] The urban heat island effect exacerbates extreme temperatures in the city, with differences in temperatures of up to 8.9°C experienced between urban and rural areas in June 2009.[38] High temperatures already significantly affect the city: 30% of energy consumption in the residential and private sector is for cooling, placing a significant pressure on the national electricity network.[39] Extreme temperatures cause issues with heat exhaustion, stress, and respiratory and cardiovascular problems, particularly for children and young people, the elderly and those with health conditions.[40]

2.2 CONSTRUCTION LANDSCAPE IN MEXICO CITY

GROWTH, VALUE AND INVESTMENTS

CONSTRUCTION SECTOR VALUE

The construction industry in Mexico is one of the largest in Latin America, forecast to be valued at $82.5 billion USD (783.8 billion MXN) in 2021, [41] with a workforce of 3.92 million. [23] In 2019, Mexico City's construction industry had a total income of 121 billion MX (12.7 billion USD). [42] Whilst Mexico's construction industry was significantly impacted by COVID-19, declining by 17.9% in 2020, it is expected to expand 9.8% in 2021, before stabilising at a an average annual growth rate of 2.6% until 2025. [43] As part of the recovery strategy, the municipal government has committed 1 billion USD (9.5 billion MX) of investment to redevelop 13 urban corridors with a focus on public infrastructure and social housing. [44] This investment is expected to create one million new jobs in the construction sector and aims to better connect communities with places of work. [44]

TACKLING CORRUPTION

Tackling corruption, which in the construction sector was often attributable to violation of building codes, has been identified as a priority for the current Mayor. [45]

EMPLOYMENT AND SKILLS

LARGE INFORMAL SECTOR

At the beginning of 2021, there were 192,800 construction workers in Mexico City, who are reportedly 97% male. [46] Approximately 85% of Mexico's construction workers are employed informally, with an average monthly salary of 5,590 MX (588 USD in 2021) compared to 7,620 MX (802 USD in 2021) for those in formal employment in the construction sector [46] and 6,480 MX (682 USD in 2021) nationally across all sectors. [30] Nationally, only 35.6% of Mexico's total workforce has access to health institutions and in 2012 1,152 deaths due to occupational risks were reported. [47] It is reported that 72,000 jobs were lost in the construction sector during 2020 as a result of the COVID-19 pandemic. [48]

INDUSTRY STRUCTURES

SMALL AND MEDIUM ENTERPRISES

Home to more construction firms (approximately 2,400) than any other city in the country, Mexico City's construction industry is of national importance. [46] Nationally, the construction sector is characterised by a large number of small and medium firms. [46] In 2020, the most important sectors of construction in Mexico City were: assets for the oil and petrochemical sector buildings, and infrastructure (including transportation). [21]

RESEARCH AND DEVELOPMENT

Mexico invests less than 1% of its gross domestic output on research and development (R&D), relative to an average of 2.4% across other OECD countries. [49] In Mexico City however 10% of large construction companies report innovation activities as part of their operations, the highest percentage in the country. [46]

CONSTRUCTION MATERIALS AND EQUIPMENT

A DESIRE FOR DURABILITY AND PERMANENCE

Interviewees reported that construction in Mexico City is typified by the use of concrete and bricks, fabricated in situ. Mexico has 35 cement plants,[50] producing 65Mt of cement in 2020[51] and in 2019 was the 20th largest exporter of cement globally.[52] Mexico is also home to Cemex, one of the world's largest international building materials companies. It was suggested by interviewees that though bricks are produced regionally, bricks are typically fired through the burning of biomass or waste products such as tyres. Resulting in carbon emissions and negatively impacting local air quality. A number of interviewees highlighted that the perception is that these materials are durable and that alternatives are less so.

INDUSTRIALISED CONSTRUCTION

One interviewee reported that though there have been examples of industrialised construction (e.g. modular, pre-fabricated structures) techniques being used across Mexico City they have not been widely adopted. The relatively cheap cost of construction labour was viewed by interviewees as a key reason why alternatives to in-situ construction techniques have not been more widely adopted.

TIMBER AND TRADITIONAL CONSTRUCTION MATERIALS

Interviewees set out that though Mexico City is rich in timber resources, these sources of timber are not managed in a sustainable way. Responsibly sourced timber is reported to be expensive and is not used widely in Mexico City outside of self-built properties. These properties generally use materials such as adobe, natural stone and timber, which typically have lower environmental impacts than concrete, but in these instances may not be sourced sustainably. Though the skills exist within the construction sector, the use of traditional construction materials such as adobe have not been scaled.

BARRIERS TO CLEAN CONSTRUCTION

The higher costs associated with more sustainable construction products was cited by interviewees as a key barrier to tackling embodied carbon, as was a lack of data on embodied carbon. It was suggested by one interviewee that designing buildings for disassembly or future adaptability was not common, and there is a limited focus on preventative maintenance. As such it is typical that many existing buildings are demolished rather than reused, as these are either too poor quality due to lack of maintenance, not fit for the proposed change of use, or because it is considered cheaper to demolish and rebuild.

CARBON FOOTPRINT

CONSTRUCTION SECTOR EMISSIONS

Mexico was the world's 11th largest emitter of greenhouse gases in 2018, emitting 695 $MtCO_2e$.[53] Despite declining its output, Mexico remains the second largest oil producer in Latin America, and oil is still one of the country's key energy sources, along with coal.[53] Mexico has a large and diverse renewable energy resource base, however wind and solar make up just 10% of the country's electricity supply.[53]

The Local Climate Action Strategy 2021-2050 indicates that Mexico City's emissions in 2016 were equivalent to 40.5 $MtCO_2e$. Of this, transportation was responsible for 61.3% emissions, stationary sources 26%, waste 12.5%, industrial processes and product use 0.31% and agriculture, forestry and other land uses 0.08%. Without action, the Local Climate Action Strategy forecasts that scope one and two emissions would increase from 27.5 $MtCO_2e$ in 2016 to 65 $MtCO_2e$ in 2050. This is equivalent to an increase of 236% in the period.[54]

2.3 CITY POWERS AND PRIORITIES

CLIMATE ACTION IN MEXICO CITY

DECOUPLING ECONOMIC GROWTH FROM FOSSIL FUELS

Mexico has developed a number of strategies and policies directly linked to climate and biodiversity action. The Nationally Determined Contribution (NDC) for Mexico submitted under the Paris Agreement pledges reduction of 22% of greenhouse gas emissions by 2030.[55] Beyond this, Mexico has committed to reducing carbon emissions to 50% below 2000 levels by 2050[56] and decoupling economic growth from fossil fuels and their environmental impacts by 2033.[57]

DECLARATIONS OF CLIMATE ACTION

The Mexico City municipal government has more ambitious goals than national targets. In November 2020, Mexico City was one of the first signatories of the C40 Clean Construction declaration. It is also signatory to the Clean Air Cities Declaration and Green & Healthy Streets Declaration, under which it pledges to set ambitious reduction targets for air pollutants; and procure only zero-emissions buses by 2025 while ensuring a major area of the city is zero emissions (in operation) by 2030.

ZERO-EMISSIONS, CLIMATE RESILIENT CITY BY 2050

The Mexico City 2025 Vision aims to reduce greenhouse gas emissions by 31.4 million tons CO_2e to a base level of 36.6 million tons CO_2e by 2025.[2] The Mexico City Local Climate Action Strategy 2021-2050 sets out eight strategic axes to achieve a zero-emissions, climate resilient city by 2050[54] and is supported by the Mexico City Climate Action program 2021-2030.[54] Districts within Mexico City are also required to design, adopt and implement Climate Action Plans. These plans must be approved by the Ministry of Environment (SEDEMA). The Mexico City Climate Action program 2021-2030 contains a series of goals, including:

- In 2024, annual emissions from the commercial, residential and services sector should not be greater than 8.7 $MtCO_2e$. Likewise, in 2030 they should not exceed 7.3 $MtCO_2e$.
- In 2024, 60% of construction and demolition waste is recycled.
- In 2024, there is zero urban growth in the Protected Natural Areas of Mexico City.
- In 2030, the exploitation of the aquifer remains at sustainable levels.

In addition to the Local Climate Action Strategy documents Mexico City has developed other local specific plans and commitments, including:

- Plan Verde which since 2007 has driven vehicle emission reductions and urban greening projects to tackle greenhouse gas emissions, air quality and climate resilience.[58]
- Zero Waste strategy that by 2024, aims to triple the amount of recycled waste – including construction and demolition waste – and reduce waste going to landfills by 70%.[3]
- The Sustainable Buildings Certification Program (SBCP) was established by Mexico City's Secretariat of the Environment and is a locally specific voluntary certification standard.[41]
- The Solar City programme, reducing annual CO_2 emissions by approximately 75 tonnes and saving the capital government around 600,000 pesos a year in electricity.[59]

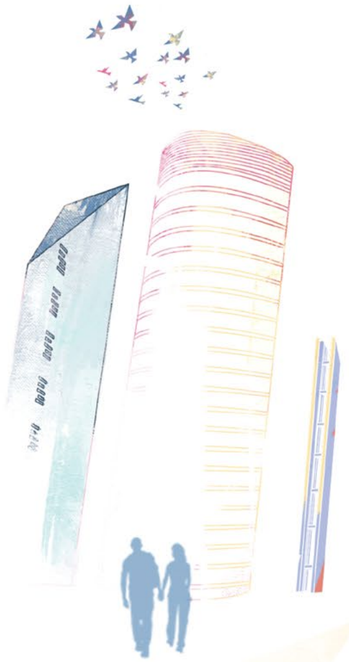
The Mexico City Local Climate Action Strategy links emissions reductions with the need to build adaptive capacity and resilience of ecosystems, infrastructure, and people. Mexico City joined the Rockefeller Foundation's 100 Resilient Cities Programme in 2013, publishing a city resilience strategy to support the city's ability to manage shocks and stresses, including those associated with climate change.[13]

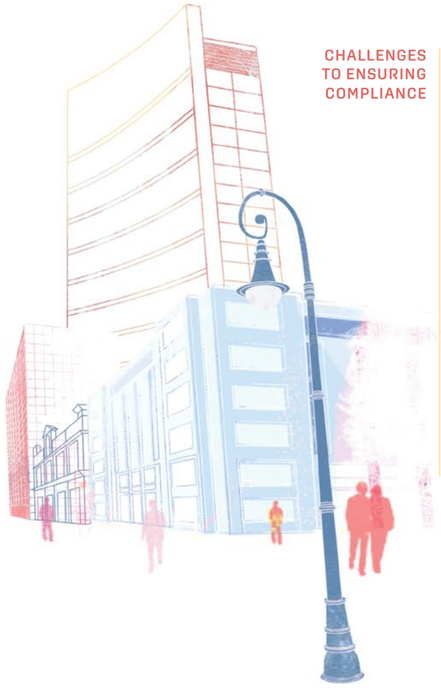
MUNICIPAL GOVERNMENT POWERS AND PRIORITIES

As illustrated in Figure 04, the municipal government of Mexico City has a relatively flexible set of powers in terms of implementing policy.

HARD IMPLEMENTATION POWERS

In terms of 'hard' implementation powers, national building codes, environmental protection standards and other regulations exist, with Mexico City managing locally specific regulations and permits. The city has the ability to set more ambitious standards and requirements than national legislation, though some minimum safety standards apply, for example seismic design codes. In 2009, Mexico City established its own SBCP and in 2016, Mexico City's Environmental Ministry unveiled updated building codes for both retrofitting and new construction.[8] International design codes are also used across Mexico. In terms of planning, the city manages construction licenses for projects compliant with the Mexico City building code, with administration for these licenses handled by district officials. Projects are required to compensate for negative externalities identified through environmental impact assessments. Provincial construction permits linked to waste, demolition and land use are also required (see Appendix A).





CHALLENGES TO ENSURING COMPLIANCE

Despite regulations, compliance rates are extremely low across Mexico.[46] Though requirements exist, it is reported that enforcement of building codes is uneven;[60] this issue was further exposed in investigations that followed the 2017 earthquake.[61] Interviewees commented on this also, highlighting the capacity of the municipal government to enforce these codes has not kept pace with the rapid urban expansion of Mexico City. Similar challenges have been reported in relation to solid waste management.[62, 63] Studies on the success of the Mexico City SBCP highlighted that high capital costs, limited government incentives and financing options are a barrier to the success of its operational energy, waste and water requirements.[8] These issues, combined with a lack of transparency on construction methods and building energy performance provide little encouragement for action.[8]

MUNICIPAL ASSETS

The municipal government has a high degree of control over public assets and services. It has a track record of investing in green roofs [64] and energy retrofits to public buildings, [65] and interviewees reported 'green products' (i.e. procurement) specifications for use in public projects. All government contracts are governed by the national Buying of Goods, Leasing and Rendering of Services of the Public Sector Law, though this is not predicated on sustainability considerations. [66] The city and state have also used financial powers to initiate sustainability policies in the city. These include green premiums on rental prices and reductions of property and payroll taxes linked to SBCP conditions, [8] a national carbon tax [67] and tax credits for research and development expenses. [68]

SOFT IMPLEMENTATION POWERS

Mexico City has relatively high flexibility to use 'soft' powers like pilot projects, developing strategies and plans, providing educational training on materials and influencing national level policy through working groups. It also has a role in international knowledge sharing initiatives, like the Ellen Macarthur Foundation, UN Building Efficiency Accelerator, and C40 Cities, among others. However, interviewees noted that in Mexico there was low engagement with public initiatives and data sharing, with little citizen engagement with the construction industry.

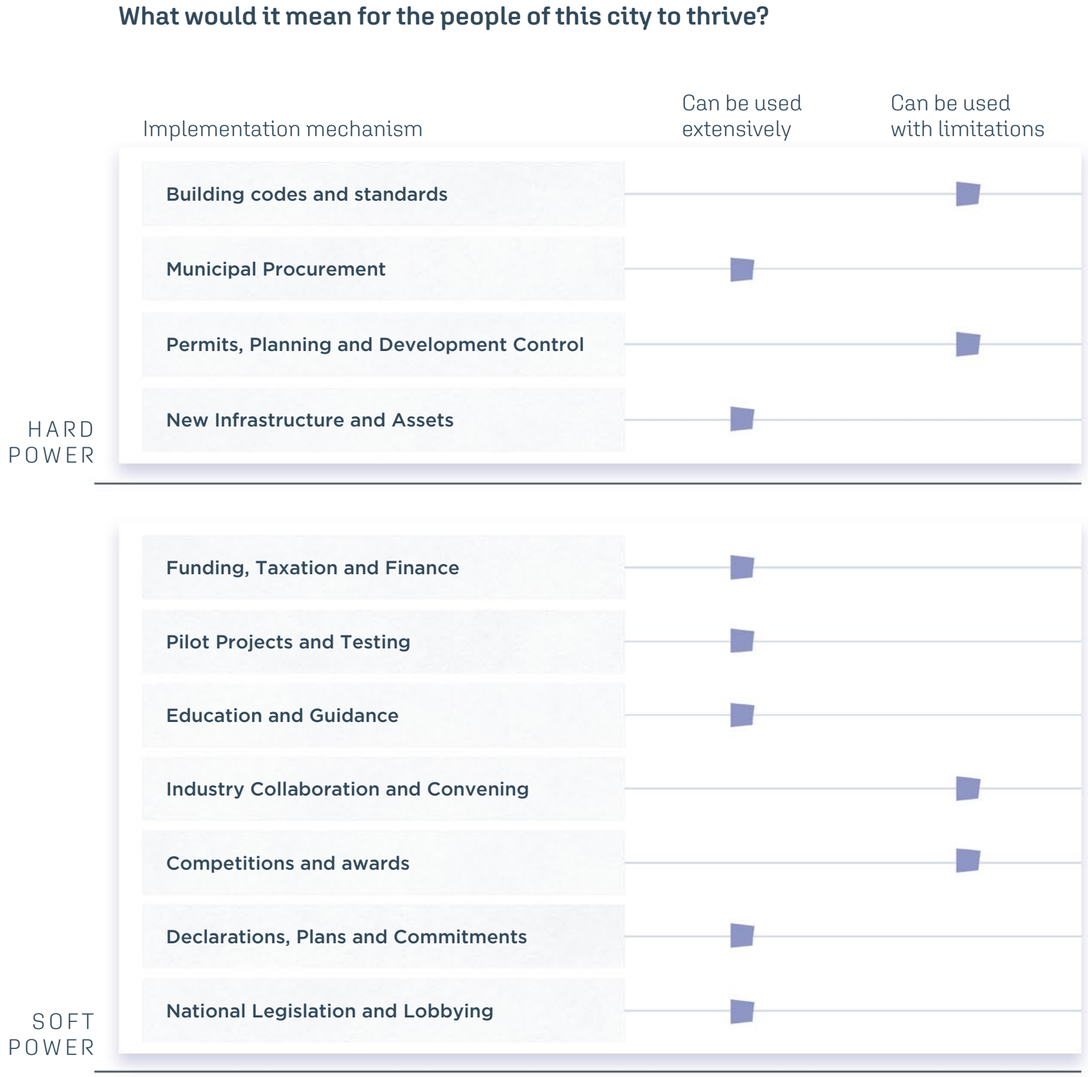


FIGURE 04
Implementation methods and mechanisms available to the municipal government of Mexico City as per power mapping analysis carried out with municipal officials

CITY PRIORITIES

Beyond GHG emissions, a number of other challenges connected to the Mexico City construction industry have been identified. Figure 05 shows the key priorities that Mexico City's built environment professionals and city officials felt 'greatly needs improvement' in the city.

	Protection and enhancement of water quality	Protection and enhancement of air quality	Encourage sustainable production and consumption practices	Foster inclusive, just and transparent governance	Affordable, high-quality and accessible housing	Mitigation of risks to physical and mental health	Reduced noise pollution	Support the creationof green jobs and skills	Sustainable management of public budgets	Environmental and health awareness and behaviour
AVERAGE SCORE	4.8	4.8	4.7	4.7	4.6	4.6	4.6	4.5	4.4	4.4

FIGURE 05
Key priorities for improvement in Mexico City

CLEAN CONSTRUCTION IN MEXICO CITY TO DATE

NATIONAL FOCUS ON ENERGY EFFICIENCY

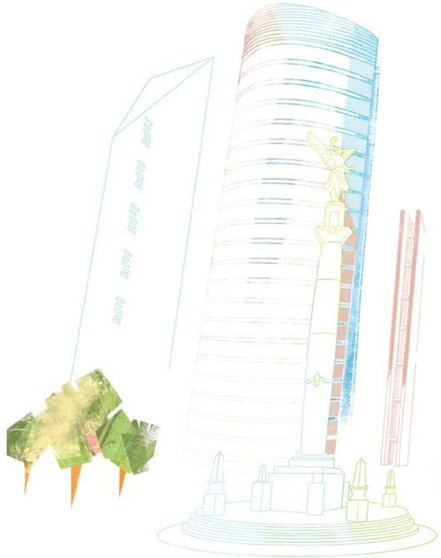
At national level, Mexico has prioritised operational emission reductions in the building sector.[69] The building energy code (IECC-Mexico) sets energy efficiency standards, and national programmes incentivise energy demand reduction activities, such as INFONAVIT's green mortgage programme and Federal Mortgage Society's EcoCasa programme.[69]

RETROFIT ACROSS MEXICO CITY

Accordingly, in Mexico City, building retrofits have risen up the agenda. The 2009 SBCP and 2016 design codes for new and retrofitted buildings are supported by financial mechanisms such as green premiums and strategic partnerships like the UN's Sustainable Energy for All and Building Efficiency Accelerator.[70] However, it was reported in 2015 that just 40 buildings had received SBCP certification, and interviewees felt retrofit campaigns have had mixed success.[71]

ADAPTIVE REUSE

There is less reference to embodied carbon in policies and programmes at either national or city level. There are however examples of adaptive reuse, circular reuse and refurbishment across Mexico City. Cuitláhuac Park for example was restored as part of the Sembrando Parques initiative, with 80-90% of materials in the park recycled CDW,[72] and the PILARES program promotes arts and culture in underutilised spaces in the city.[73] There have been high profile examples of derelict buildings being refurbished,[72] or converted.[75] Interviewees also reported that local sourcing of materials is stipulated as a requirement in all publicly funded construction projects.



SKILLS FOR CLEAN CONSTRUCTION

Following the 2017 earthquake, around 48% of the 2,458 damaged buildings in Mexico City are fully operational, despite disruption by the COVID-19 pandemic.[11] Though interviewees identified that demolition was often favoured over refurbishment, these recovery efforts suggest a strong existing skills base is available to support refurbishment.

ALTERNATIVE CONSTRUCTION MATERIALS

There is evidence of informal settlements using low embodied carbon construction products, including timber, though sustainability of supply and quality of buildings are not assured, and the use of bio-based materials in the formal sector is low. Despite these constraints, there is a great deal of interest in alternative construction typologies and national building codes for the use of timber already exist.

CONSTRUCTION WASTE MANAGEMENT

In terms of waste management, Mexico City generates about 14,000 tons of CDW daily, with low recycling rates. Mexico City has two CDW recycling plants and one more under construction, as well as updates to related legislation to encourage recycling, reuse and correct final disposal,[76] such as the adopted NADF-007-RNAT-2019, which sets out classifications and guidance on management of different waste types.[10]

LABOUR STRATEGY

Public and private training and skills development that incorporate clean construction topics already exist in Mexico City, ranging from students to existing workers and industry leaders. The city's new labour strategy focusses on the circular economy, environmental protection and industry,[77] with publicly-funded worker training available on sustainable design and construction.[54] Organisations, such as Échale a Tu Casa,[78] aim to build capacity in low income, marginalised and disadvantaged communities.

Further detail on actions aligned with the principles of clean construction are set out in Appendix D.

THE RETROFIT AND REPURPOSING OF MEXICO CITY'S HISTORIC BUILDINGS

CONDESA NEIGHBOURHOOD

Mexico City's Condesa neighbourhood largely grew in the late 19th and early 20th Century, as a home to Mexico City's wealthy residents. The area had already begun to experience decline as residents relocated to new, car-friendly neighbourhoods in the west of the city, before Condesa was severely damaged in the 1985 earthquake causing property prices to fall and buildings to be abandoned.[79] Condesa has since bounced back, predominantly due to its proximity to the city's financial centre. The neighbourhood was damaged again in the 2017 earthquake. Since then, some of Condesa's Art Deco buildings have been sensitively restored, such as the Edificio Basurto,[80] whilst many other buildings have undergone post-earthquake repairs and retrofit with new steel plates over existing concrete columns.[81]

ROMA NEIGHBOURHOOD

The adjacent Roma neighbourhood has a similar history and is home to many of the city's most famous Art Deco architecture, as well as housing 10% of the country's designated artistic monuments.[82] One of the most notable examples adaptive reuse in Mexico City is the conversion of a derelict Roma block into a vibrant, mixed-use space. The design retained exposed brick, concrete beams, wooden floorboards, and door frames from the original space.[83]

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Today these two neighbourhoods are often described as Mexico City's 'Soho'. The processes of maintenance, refurbishment, and retrofit in these neighbourhoods illustrate the significant skills that exist within Mexico City. Skills can be built upon to promote greater maintenance and reuse of the existing building stock, to tackle high levels of demolition and rebuild. However, the urban regeneration of Condesa and Roma into trendy and economically dynamic neighbourhoods has also fuelled a simultaneous process of gentrification; rental prices have skyrocketed and both areas rank in Mexico City's top ten most expensive neighbourhoods.[84] As a consequence, long-time residents and local businesses have been displaced.[85] This illustrates the importance of assessing equity and inclusion in the development and implementation of clean construction measures.

2.4 CLEAN CONSTRUCTION RECOMMENDATIONS FOR MEXICO CITY

Mexico City is an influential and fast-changing city. It has an existing set of ambitious proposals to manage urban development, reduce operational energy emissions and build climate resilience. Urban planners and architects in Mexico City are pioneering the adaptive reuse of the public realm and buildings, and the city is rapidly developing new infrastructure systems to manage waste and water. There have been significant efforts nationally and within the city, to repair and rebuild following the catastrophic impacts of the 2017 earthquake. Mexico City as such is in a strong position to integrate ambitious clean construction measures into this list.

In our analysis, we initially identified a longlist of clean construction measures for Mexico City. The analysis demonstrated that there were a range of measures that could be considered across each stage of the clean construction hierarchy. A summary of all viable clean construction measures in Mexico City considered through this study are presented in Appendix E.

Only one clean construction measure was considered not applicable to Mexico City:

- Local, regional, national and international codes are all used in Mexico City, and the seismic design code is a priority to local engineers, according to interviewees. As such, a measure linked to changing structural design codes to maximise material efficiency was removed.

Seven ‘highly recommended’ clean construction measures were identified. The selection was based on their potential impact and feasibility in Mexico City, and their alignment with the key benefits identified for the city through a series of interviews, surveys, and desktop analyses. A description of the priority clean construction measures is provided on the following page. How these build on actions already underway in Mexico City and the view of interviewees are presented in in Figure 06. Additional benefits of the measures are discussed in Figure 07.

PRIORITY CLEAN CONSTRUCTION MEASURES SELECTED FOR MEXICO CITY

USE PRE-FABRICATED, OFF-SITE AND MODULAR CONSTRUCTION METHODS

Adopting industrialised construction methods can have a number of benefits. Fabricating building components in controlled environments can reduce waste, improve quality, and simplify construction site activities. Construction programmes are shorter and vehicle movements fewer, reducing disruption for communities and protecting the health of citizens. These methods also enable the production of buildings rapidly and affordably.

ADAPT AND REFURBISH STRUCTURALLY SOUND BUILDINGS RATHER THAN DEMOLISH

Extending the lifespan of the building stock can be achieved through building refurbishment. This action would build on local expertise, as evidenced through works in the Condesa Barrio area and associated with the recovery efforts following the 2017 earthquake. These actions can be combined with deep energy retrofits [86] which similarly help extend building lifespans and raise real estate value.

PROMOTE ALTERNATIVE USES FOR VACANT AND UNUSED STRUCTURES

Often, buildings are underutilised and discarded before they have reached the end of their useful life. Interviewees noted several speculative developments in Mexico City financial centres may be underutilised - an issue exacerbated by the impacts of COVID-19. Repurposing underutilised spaces can avoid buildings being demolished, limit further urban sprawl and unlock co-benefits for citizens, assets owners and the municipal government.

USE BIO-BASED MATERIALS AND CERTIFIED TIMBER PRODUCTS

Such actions will reduce the embodied carbon associated with new build and refurbishment across Mexico City. Though design codes exist for alternative materials, and there is evidence of these and traditional materials being used across the city, interviewees cited cost, availability, regulation, and data as key barriers to wider use at present. As such, this measure addresses these barriers to promote wider use. Achieving this will require engagement from all parts of the construction supply chain.

BUILD PHYSICAL WASTE PROCESSING INFRASTRUCTURE, INCLUDING MATERIAL REUSE FACILITIES, RECYCLING CENTRES AND LOCAL MATERIALS DISPOSAL ROUTES

Such infrastructure is the backbone and enabler of successful clean construction interventions across the city. This recommendation supports the existing commitments made by the municipal government for investment in waste management infrastructure in line with the Zero Waste strategy. Where infrastructure is sited must be carefully considered, in relation to demand for reused and recycled components as well as potential impacts for citizens.

COLLECT AND SHARE DATA ON CLEAN CONSTRUCTION INITIATIVES AND LESSONS LEARNT

Improving data collection and transparency on construction methodologies is essential to monitor progress, understand where municipal government support is needed, track material and waste flows and build a knowledge base. This data will be beneficial for Mexico City in informing the development and implementation of clean construction measures. Equally, this data should be available to the wider construction sector, to build their understanding and inform decision making.

ESTABLISH REGULAR MAINTENANCE PROGRAMMES TO REPAIR AND RETROFIT EXISTING BUILDINGS

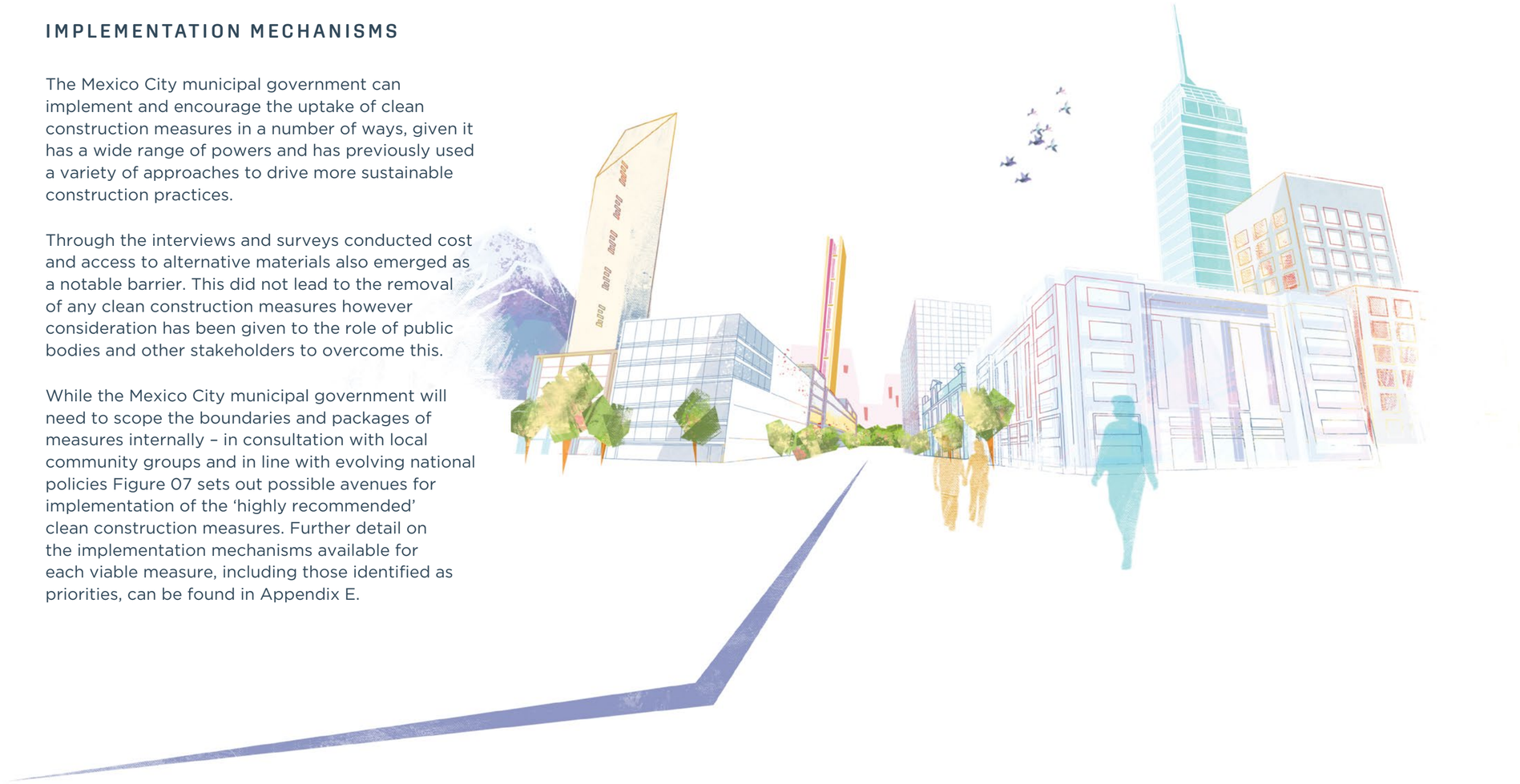
Regular maintenance programmes can help to extend building lifespans, in turn minimising rates of demolition and rebuild, and optimising the performance of existing buildings. Interviewees indicated there is not a culture of preventative maintenance in Mexico City, though a number of public assets have established programmes that could inspire action on behalf of others.

IMPLEMENTATION MECHANISMS

The Mexico City municipal government can implement and encourage the uptake of clean construction measures in a number of ways, given it has a wide range of powers and has previously used a variety of approaches to drive more sustainable construction practices.

Through the interviews and surveys conducted cost and access to alternative materials also emerged as a notable barrier. This did not lead to the removal of any clean construction measures however consideration has been given to the role of public bodies and other stakeholders to overcome this.

While the Mexico City municipal government will need to scope the boundaries and packages of measures internally – in consultation with local community groups and in line with evolving national policies Figure 07 sets out possible avenues for implementation of the 'highly recommended' clean construction measures. Further detail on the implementation mechanisms available for each viable measure, including those identified as priorities, can be found in Appendix E.



Priority clean construction measures.	How do these measures build on what Mexico City is already doing?	What insights did interviewees share about this measure?	Key implementation mechanisms.
Clean Construction Hierarchy: Prioritise existing assets			
PROMOTE ALTERNATIVE USES FOR VACANT AND UNUSED STRUCTURES	There are a number spaces within the city known to be underutilised or vacant; as much as 11% of A and A+ commercial offices.[87] Successes from other adaptive reuse and regeneration projects[74, 75, 73, 12] should be shared to encourage wider action in this area. This measure aligns with goals to promote more inclusive and equitable land use planning in the Mexico City Local Climate Action Plan.[54]	Interviewees highlighted issues of vacancy rates are particularly high in speculative developments, and that the issue has been deepened by the impacts of the COVID-19 pandemic. Interviewees suggested that there as such may be an opportunity to integrate change of uses in underutilised commercial office spaces, with a focus on creating mixed use developments, quality homes and other civic functions for which additional capacity is needed in the city. At present in Mexico City however, interviewees suggested that it is generally perceived to be cheaper and easier to demolish and rebuild.	■ Incentivise conversion of vacant space through financial incentives, as in the SBCP. Develop strategic plans to encourage mixed use development within underutilised areas. Establish shared ownership models (e.g. public-private partnerships) or buy vacant space, rather than build new. A simplified and expedited permitting system could encourage greater adaptive reuse. This could be supplemented by monitoring vacancy rates across the city. Data could be combined with additional analysis, community and business forum consultation to inform proposals for change of use.
ADAPT AND REFURBISH STRUCTURALLY SOUND BUILDINGS RATHER THAN DEMOLISH	Building refurbishment is normal in Mexico City after seismic events,[11] and numerous neighbourhoods have undergone significant refurbishment for regeneration programmes.[75] Though not a regulatory requirement, the SBCP encourages building reuse over demolition. The Mexico CIty Local Climate Action Plan aims to reduce demolition waste (Axis Three) and limit further urban sprawl (Axis Five).[54]	Interviewees reported companies that remodel an existing building do not pay taxes, with a discount of up to 70% for three years. Interviewees highlighted that this action must be taken in parallel with a city-wide maintenance programme. Often it is perceived that it is cheaper to demolish and rebuild as structures often lack maintenance. In addition, the low rates of compliance with building code means it is often perceived as 'easier' to start from scratch than request permits for reuse.	■ Make permits for refurbishments and retrofit easier to attain, and disincentivise demolition through financial penalties or similar. These actions could be incorporated within future iterations of regulatory requirements such as NADF-007, building on existing efforts in this standard and the SBCP. It is noted that the additional priority actions focused on establishing regular maintenance programmes will help address demolition.
ESTABLISH REGULAR MAINTENANCE PROGRAMMES TO REPAIR AND RETROFIT EXISTING BUILDINGS	As set out above, there is a strong existing skill base to support maintenance, repair and retrofit programmes. Studies have set out detailed roadmaps to upscale retrofits in the city,[88] which also contribute to the development of skills in this area.[65] Promoting adaptation and refurbishment will directly support the Mexico City Local Climate Action Plan by reducing demolition waste (Axis Three).[54]	Interviewees reported that across the city there is a limited culture of preventative maintenance. Where this does exist, it is typically in large buildings or those owned / operated by multi-nationals. For others, cost is viewed as a key barrier and there is limited regulation requiring action otherwise. In turn, buildings become dilapidated over time and this fuels a cycle of demolition and rebuild.	■ Establish preventative maintenance programmes across all publicly owned assets. The costs and outcomes associated with this could be shared widely, and inform the development of pilot incentives, co-benefits research, monitoring and accreditation schemes and other schemes to drive uptake of repair and retrofit schemes.[88] Use regulatory powers to require and incentivise action by private asset owners. Lobby national government for a greater focus on maintenance of existing assets.

FIGURE 06
Summary of highly recommended clean construction measures for consideration in Mexico City

Priority clean construction measures.	How do these measures build on what Mexico City is already doing?	What insights did interviewees share about this measure?	Key implementation mechanisms.
Clean Construction Hierarchy: Use materials efficiently and switch to low-carbon alternatives | Plan design and build for the future			
USE BIO-BASED MATERIALS AND CERTIFIED TIMBER PRODUCTS	Alternatives to steel, concrete and brick are not widely used outside the informal and self-build sector. Timber is abundant regionally but sources are not sustainably managed. Regional timber design codes do exist and provide a regulatory framework for designers. In the self-build and informal sector, the use of alternative and traditional construction materials is more prevalent.	It was generally acknowledged by interviewees that this topic is likely to emerge as a priority for the construction sector in Mexico City and Mexico. Interviewees had mixed opinions on why lower carbon materials were not more widely used, citing a general lack of demand, anticipated cost uplift associated with these materials, or a cultural desire for 'permanence', with some believing that the construction industry views timber and other lower carbon materials as less durable and therefore less desirable. Others felt there is a limited understanding of the benefits of lower carbon materials are required.	■ Stimulate market demand by requiring whole life carbon assessments and Environmental Product Declarations (EPDs) in specifications, planning permits and building codes. Produce technical guidance or deliver pilot and flagship projects and share the outcomes / benefits of these. Provide financial incentives for those producing low carbon construction materials. Municipal government projects, such as the Special Program for Urban Regeneration and Inclusive Housing could lead by example. It is understood there are existing programmes on sustainable forest management:[89] consider new programmes for timber certification.
USE PRE-FABRICATED, OFF-SITE AND MODULAR CONSTRUCTION METHODS	Though there have been examples of industrialised construction techniques being used in the residential sector across Mexico these have been reported to have mixed success. Notably, no evidence suggests they have become widely adopted. Lessons learnt from initiatives such as INFONAVIT, which offers credits to vulnerable and marginalised individuals to support with the purchase of modular prefabricated homes, can be built upon.	Interviewees noted past designs (not INFONAVIT) for homes using similar techniques were poor (i.e. small, uncomfortable) and this has created a cultural barrier. An additional challenge highlighted was the relatively cheap cost of construction labour, which in turn limits the benefit of a key benefit typically associated with industrialised construction – speed of manufacture. That said, the opportunity this measure poses for material efficiency improvements as well as construction worker welfare was acknowledged.	■ Work in partnership with the Construction Council, architectural and engineering schools and others to quantify and disseminate the multiple benefits that might be realised through industrialised construction. Future public projects may be used as pilot or flagship projects to inform this as well as lead by example. Significant investments in infrastructure are planned,[41] future investment 'packages' could consider establishing a hub for industrialised construction.

FIGURE 06 CONT.
Summary of highly recommended clean construction measures for consideration in Mexico City

Priority clean construction measures.	How do these measures build on what Mexico City is already doing?	What insights did interviewees share about this measure?	Key implementation mechanisms.
Supporting and enabling actions			
BUILD PHYSICAL WASTE PROCESSING INFRASTRUCTURE: MATERIALS REUSE FACILITIES, RECYCLING CENTRES, LOCAL MATERIALS DISPOSAL ROUTES	The 2019 Mexico City Zero Waste strategy outlines a commitment to tripling recycling rates by 2024, including C&D waste.[3] The 2021 NADF-007 standard specifies actions for resource efficiency, recycling and reuse in construction projects.[10] Additional infrastructure is being funded through public-private partnerships to increase the processing capacity of Mexico City.[3]	Interviewees felt compliance with regulatory requirements, such NADF-007, is assured for large developments, but the municipal government does not have the capacity to review and confirm compliance across all development in the city. This is a challenge as meeting the ambitions of the Zero Waste strategy requires a strong market for the recycling and reuse of C&D waste. Building greater infrastructure capacity was viewed as a unique opportunity by interviewees.	■ Monitor impacts of new waste actions pipeline projects and standards like NADF-007, using findings as evidence for bolder and even more ambitious action. Other existing actions could be iterated upon, such as developing financial incentives for manufacturers to drive use of recycled and reused construction products, or updating public procurement documents and price catalogues to encourage the use of reused materials.
DEVELOP CLEAN CONSTRUCTION TRAINING, GUIDELINES AND TOOLS	Mexico and Mexico City are participating in a number of international forums and programmes. Through these, lessons are being learnt from other participating cities. A number of private organisations deliver training through their work,[78] though these actions could be scaled. Mexico City has a strong network of universities in or close by the city. This measure could build upon or be integrated within the engagement programmes proposed within the Mexico City Local Climate Action Plan (Axis Eight).[54]	Interviewees highlighted that education programmes have a critical role to play in unlocking action on clean construction. Greater collaboration between the municipal government and the districts, external organisations and institutions such as the Construction Council, Mexican Chamber of the Construction Industry (CMIC) and architectural and engineering school was highlighted as a key need, as knowledge sharing is currently limited. One interviewee felt the simple messaging in the Zero Waste strategy had built the success of building engagement with the plan.	■ Collaborate across the construction sector and beyond to leverage the influence and expertise of other groups, and roll out training and skills programmes for the construction sector. This may influence curriculums taught in academic institutions, programmes of talks or competency requirements managed by professional institutions, or be delivered in site cabins as part of site setup activities. Lead by example through public projects by setting requirements for the creation of skills-based apprenticeships or similar.

FIGURE 06 CONT.
Summary of highly recommended clean construction measures for consideration in Mexico City

Appendix F shows a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of key challenges and opportunities related to the clean construction measures and implementation mechanisms highlighted as relevant to Mexico City, with the challenges identified by interviewees or in the literature review. The SWOT assessment highlights several enabling actions that could inform the design and implementation of clean construction policy in Mexico City:

- **EMBRACE THE OPPORTUNITY CLEAN CONSTRUCTION OFFERS TO BUILD A MORE INCLUSIVE, EQUITABLE AND RESILIENT COMMUNITY AND CONSTRUCTION WORKFORCE ACROSS MEXICO CITY:** It is clear that the development of clean construction measures offer a significant opportunity to address challenges related to inclusivity, equity and resilience.[13] Rigorously testing proposed measures using tools such as the C40 equity assessment as well as creating greater opportunity for citizen engagement in the development process will be vital to achieving this. The development of some measures may be supported by conducting layered spatial analyses of the city to map derelict housing, vacant assets and other potential buildings for refurbishment against socio-spatial data, to shape proposals around the needs of vulnerable or high-risk neighbourhoods.

- **BUILD CAPACITY WITHIN THE MEXICO CITY MUNICIPAL GOVERNMENT AND ACROSS THE DISTRICTS TO ACHIEVE GREATER REGULATORY COMPLIANCE:** Low rates of compliance with existing regulations and initiatives is a systemic issue in Mexico City. Issues of corruption have also contributed to this as set out earlier. Building capacity across the regulatory bodies to ensure legislative requirements can be more effectively managed and implemented, across a greater proportion of development in the city will be vital to the success of clean construction measures.

- **DEVELOP SPECIFIC REGULATIONS AND INCENTIVES FOR SMALL CONSTRUCTION PROJECTS AND SELF-BUILDING:** The nature of construction in Mexico City is diverse. Interviewees reported that smaller companies typically have lower compliance rates with environmental regulations. In addition to building the capacity of municipal government to work with this sector of the construction industry, developing specific design codes, technical guidance documents and incentives for these cases will enable scaling and acceleration of clean construction outcomes.

- **LEVERAGE THE WEALTH OF EXISTING EXPERTISE AND INITIATIVES THAT ALIGN WITH CLEAN CONSTRUCTION PRINCIPLES:** There are many existing examples of ambitious clean construction and circular economy measures in Mexico City, with pioneering cases of adaptive reuse and refurbishment, locally-specific and ambitious new strategies for construction and demolition waste. The successes of these initiatives and actions taken to drive clean construction outcomes to date should be celebrated and shared widely, and be used to begin to introduce a wider set of clean construction principles to the city. In addition, the Local Climate Action Plan incorporates a number of measures that can be leveraged to deliver clean construction outcomes.[54]

- **DRIVE A NEW MINDSET FOR CONSTRUCTION BY RAISING AWARENESS OF CLEAN CONSTRUCTION DESIGNS, MATERIALS AND PROCESSES, DEBUNKING ANY FALSE PERCEPTIONS AND EMPHASISING THE BENEFITS:** Interviewees noted that many existing regulations and initiatives linked to cleaner construction in Mexico City were effective, but saw low uptake rates and poor levels of compliance. There is both a need to raise awareness of not only what clean construction measures are but why they are needed and how they can contribute to wider benefits across the city and for citizens' quality of life. Coupled with action to build the capacity of the municipal government to better enforce compliance with standards, the city can instigate change through leading by example in the management and procurement of public assets.

- **CONSULT AND ENGAGE WITH INDUSTRY STAKEHOLDERS TO SHAPE CLEAN CONSTRUCTION POLICIES:** Many interviewees stressed that knowledge sharing, industry convening and public-private partnerships are relatively uncommon in Mexico City, in part attributed to a lack of dialogue, and disinterest in sustainability initiatives in the private sector.[88] By engaging closely with industry, the Mexico City municipal government will be able to shape effective policies and approaches to clean construction and build early engagement and support for these, supporting their successful implementation. This could draw on support and resources from the many national programs and networks the city participates in (including C40 Cities, UNEP and the Ellen Macarthur Foundation).

2.5 BENEFITS AND IMPACTS FOR MEXICO CITY

Implementation of clean construction policies in Mexico City will not only reduce emissions associated with building and construction, but also yield global and local benefits linked to social and environmental impacts (Figure 03). These are summarised in Figure 07 for the 'highly recommended' clean construction measures and implementation mechanisms suggested in Section 2.4. Crucially, the measures and implementation mechanisms suggested will help deliver many of the key concerns noted by interviewees for Mexico City.

LOCAL SOCIAL

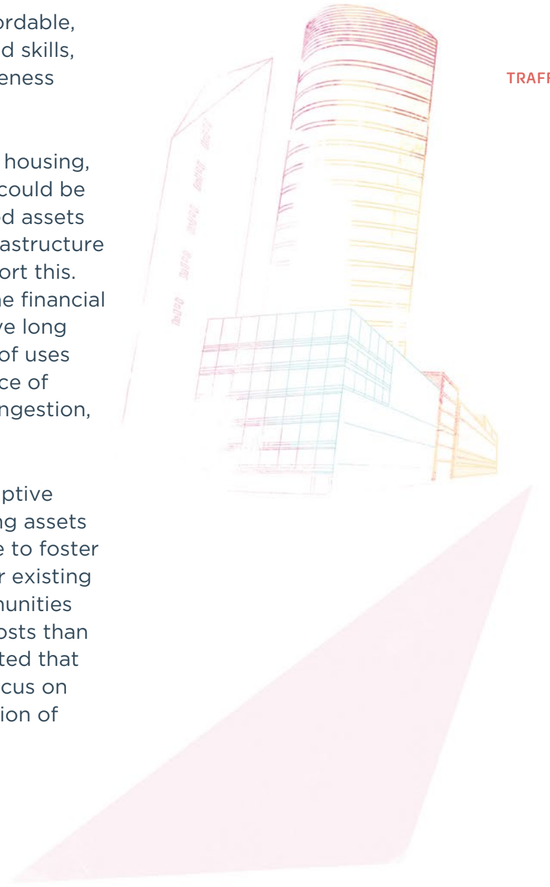
Key local social priorities for Mexico City were affordable, high-quality and accessible housing, green jobs and skills, public budget and environmental health and awareness (Figure 05).

MIXED USE, AFFORDABLE NEIGHBOURHOODS

In terms of affordable, high-quality and accessible housing, interviewees noted significant benefit for citizens could be derived from repurposing existing but underutilised assets to create new homes. Although assessment of infrastructure capacity in these areas would be required to support this. This particularly applies to commercial assets in the financial centres, to which many service sector workers have long daily commutes. Through promoting a better mix of uses in such areas, citizens could live closer to their place of work. In turn this would help reduce traffic and congestion, increase road safety and tackle poor air quality.

PROTECT COMMUNITY TIES AND HEALTH

Studies conducted in other cities suggest that adaptive reuse - achieved through refurbishing or retrofitting assets - better retains community identity and does more to foster local pride, [90] has fewer negative consequences for existing communities [91] and causes less disruption to communities and residents. [92] It also has lower overall lifetime costs than demolition and construction. [92] In turn, it is suggested that the recommended clean construction measures focus on adaptive reuse in Mexico City to support the creation of more vibrant, thriving and resilient communities.



IMPROVE AIR QUALITY AND REDUCE ROAD TRAFFIC ACCIDENTS

Construction sites are dangerous environments in which to work, both minor and fatal injuries are not uncommon. Similarly, transporting materials to site increases the risk of road accidents and has a negative impact on local air quality and in turn the health of citizens. Industrialised construction methods offer an opportunity to reduce the amount of time spent on site, tackle air pollution through simplifying the construction process, limiting worker exposure to hot weather and reducing vehicle movements. This is achieved through moving a significant proportion of the fabrication process into a controlled environment. Also as building components are produced in a controlled environment the quality of the build can be better managed and assessed. [93] It is often cited that the ‘industrialised’ nature of pre-fabricated and modular construction means that buildings can be delivered at scale faster and cheaper, which contributes to rapid development of an affordable housing stock. [94] This measure supports priorities around green jobs and sustainable use of the public budget.

JOB CREATION ALIGNED WITH LOCAL SKILL BASE

Interviewees suggest programmes of preventative maintenance are not common, but there is significant existing knowledge and skills in this area. [11] Establishing a programme focused on preventative maintenance would utilise this skills base and create a significant number of green jobs. [95] Similarly there are existing skills in the use of traditional, lower carbon construction materials. The use of these materials could be scaled and integrated into circular economy initiatives and funding streams, creating green jobs in an area with a high existing skills base. In addition, green jobs will be created through the construction of waste infrastructure.

LOCAL ECOLOGICAL

Key local ecological priorities for Mexico City are water quality, noise pollution and air quality (Figure 05).

REDUCE ENVIRONMENTAL POLLUTION

With regard to air, water and noise pollution, both repurposing underutilised existing assets and prioritising refurbishment over demolition would reduce overall demand for demolition and rebuild. Less demolition and new construction reduces disruption to communities, including air and noise pollution and waste dumping.[13] This can mitigate dust deposition for example, which over long periods impacts soils and watercourses, affecting sensitive habitats and biodiversity.[96]

A shift to industrialised construction techniques also supports this, through moving a proportion of site works to an indoor environment away from these communities.[94, 93] Similarly, citizens of Mexico City are highly dependent on the ecosystem services afforded by the 'water forest'. Reducing the demand for new build would alleviate pressures on this ecosystem associated with urban sprawl.

PROTECT ECOSYSTEMS

Similarly, switching to sustainably sourced timber and bio-based materials can improve local environmental quality. Studies have shown that deliveries to construction sites can be reduced by 60% where timber is used over cement and steel.[97] Corresponding savings on fuel and greenhouse gas emissions associated with these actions could be anticipated. Building the capacity of waste management and treatment infrastructure across Mexico City will also mitigate well-documented challenges of greenhouse gas emissions and local environmental pollution associated with today's waste management system.[62]

GLOBAL SOCIAL

Key global social priorities for Mexico City were green jobs and skills (see also local social) and good governance (Figure 05).

GLOBAL CAPACITY BUILDING

As evidenced by campaigns such as RetroFirst,[98] some cities and organisations have created international campaigns around clean construction measures. These could be used to build knowledge and skills regionally, but also invite global innovation as to how adaptive reuse may be realised in Mexico City.

FAIR AND JUST SUPPLY CHAINS

Reducing demand for materials, through promoting adaptive reuse and refurbishment, and encouraging the specification of 'lower impact' materials helps reduce risks for communities across the globe involved in the material supply chain. These actions support global efforts to combat issues of resource scarcity (e.g. water) and pollution (e.g. land contamination or air quality) in those communities working or living next to mining and extraction zones. Data collection, training and education helps highlight and track issues to be raised and considered by project teams in Mexico City and nationally, informing the development of new policy and regulation.

GLOBAL ECOLOGICAL

Key global ecological priorities for Mexico City were sustainable production and consumption and water quality (Figure 05), also refer to local ecological.

REDUCE MATERIAL USE

To fully meet Mexico City's climate action ambitions, greater emissions reductions and a substantially reduced use of materials can be driven across the supply chain through a move to refurbishment and retrofit of buildings in place of demolition and rebuilding, underpinned by a circular, adaptive construction industry. Cities are responsible for over 70% of global CO_2 emissions [99] and construction currently contributes more than 23% of the world's greenhouse gas emissions. [1] Tackling embodied emissions from the construction sector would dramatically help with tackling the climate crisis.

MINIMISE WHOLE LIFE CARBON

Mexico City has grown rapidly and is continuously evolving. It is material hungry and at present, the materials most used are those that also have the highest embodied impacts. [100] Reducing demand for these materials supports greenhouse gas emission reductions as well as mitigating ecological risks across the supply chain. [101] The development of waste processing infrastructure, together with financial and market incentives to use recycled materials in construction, supports the development of robust markets for salvaged and recycled materials, in turn encouraging designers, contractors and developers to use them as an alternative to newly manufactured materials, as well as reducing waste. [102] C40, Arup and the University of Leeds tested clean construction scenarios linked to reduced use of materials (including reductions in new building demand, use of low carbon cement and reuse of building materials) to understand how they might help reduce a city's consumption-based emissions reductions, finding that cities could reduce consumption-based emissions by at least 44% (by 2030, against a 2020 baseline). [103]

Priority clean construction measures.	Carbon emission reduction potential	Other benefits to Mexico City	Cost of inaction
Clean Construction Hierarchy: Prioritise existing assets			
PROMOTE ALTERNATIVE USES FOR VACANT AND UNUSED STRUCTURES	Research suggests that if cities optimise the use of existing structures, consequently reducing the need for new buildings, they could potentially cut GHG emissions by 11% between 2017 and 2050.[103] This also provides an opportunity to achieve significant emission reductions associated with mobility.[5]	This action could facilitate the transformation of financial centres into mixed use developments. In turn, helping to tackle issues of congestion, road traffic accidents, local air pollution and general quality of life for many citizens.[5] Interviewees saw this as a significant opportunity to address the demand for high quality housing. As evidenced through PILARES[73] and Sembrando Parques,[12] adaptive reuse can restore and enhance ecological value of unused public spaces and contribute to building regional adaptive capacity to the impacts of climate change.	Without action, the process of urban sprawl may continue and there is potential that issues such as the urban heat island and illegal encroachment into the water forest would worsen. For many, long commutes would remain typical, missing opportunities to tackle air quality, congestion and road traffic accidents.
ADAPT AND REFURBISH OF STRUCTURALLY SOUND BUILDINGS RATHER THAN DEMOLISH	Though contexts will vary, the whole life carbon associated with retrofit is typically lower than that of demolition, rebuild and housing residents in modern, low energy demand homes.[104]	Research also suggests that refurbishment is more cost effective than demolition and rebuild[104] and causes less disruption for communities.[92] Refurbishments improve indoor environments, tackle asbestos, mitigate the risks of diseases and mortality and tackle fuel poverty.[86] Building refurbishment is, therefore, an urban policy measure with multiple broader benefits – not only do they reduce greenhouse gas emissions, but they help to address inequalities and improve social cohesion in cities.[86] Expanding the demand for refurbishment can generate green jobs, supporting national priorities and utilising the skills of local citizens.[54]	In addition to those consequences set out above, without action the process of demolition and rebuild would continue. In turn, generating significant amounts of construction 'waste' and associated greenhouse gas emissions. For citizens of Mexico City, continued demolition and rebuild would not support in alleviating current issues of poor air quality, noise, watercourse pollution and high volumes of construction traffic. Overarching all this, achieving the greenhouse gas emission commitments set out by the city would be at risk without action.
ESTABLISH REGULAR MAINTENANCE PROGRAMMES TO REPAIR AND RETROFIT EXISTING BUILDINGS	Interviewees reported that a lack of preventative maintenance culture fuels the cycle of demolition and rebuild, as when assets are sold they are often dilapidated and it is viewed as cheaper and easier to start again. Tackling this culture could derive significant benefits through keeping buildings in use for longer.	Regular maintenance could deliver significant co-benefits associated with community resilience, especially regarding access to basic services and utilities.[32] Retrofit and maintenance programmes have the potential to create new and higher skilled jobs within the construction sector.[95] Planned preventative maintenance can improve operational efficiency for the building owner and occupier.[105] This increases resilience and reduces possible downtime, ensuring healthy and safe environments for staff, as well as maximising asset value.[105]	Without action, opportunities to improve the quality of living and working conditions for many will be missed. Building owners and occupiers will not benefit from cost savings associated with improved building performance and overtime, and asset values will decrease more rapidly. Notably, if not implemented on historically significant buildings the cultural value of these assets may be lost. If the cycle of demolition and rebuild is not curtailed, there will be significant missed opportunity for making meaningful reductions in greenhouse gas emissions.

FIGURE 07
Summary of emissions reductions and benefits of 'highly recommended' clean construction measures

Priority clean construction measures.	Carbon emission reduction potential	Other benefits to Mexico City	Cost of inaction
Clean Construction Hierarchy: Use materials efficiently and switch to low-carbon alternatives | Plan design and build for the future			
 **USE BIO-BASED MATERIALS AND CERTIFIED TIMBER PRODUCTS**	Switching high-emission materials to sustainable timber where appropriate could cut GHG emissions by 6% between 2017 and 2050.[103] In addition, reducing the need for cement in concrete by using lower-carbon alternatives could potentially cut GHG emissions by 6% over the same period.[103] Adobe and soil-concrete materials are other avenues for reduced carbon intensity through bio-based materials.	The introduction of sustainable manufacturer management practices and stricter regulation of sources of timber could unlock a number of benefits. For example, species conservation, aquifer recharge, improved soil quality and carbon storage. In turn, this would enhance the ecosystem service benefits derived for the local community. Promoting the use of bio-based materials could create a new market for traditional construction methods, generating local jobs for citizens. There is a growing international market for bio-based materials also.[106] Reductions in deliveries to construction sites of up to 60% where timber is used over cement and steel, may be possible.[97]	■ Continued practices of illegal logging and as a consequence, poor forest management. In turn, these practices will continue to compromise and reinforce challenges linked to the provision of ecosystem services to Mexico City and its citizens, including aquifer recharge and water access. Mobility, air quality and road traffic safety are some of the key resilience challenges facing Mexico City.[13] These issues also impact on the city's competitiveness, productivity, and local environment. Not taking action is a missed opportunity to tackle these issues.
 **USE PRE-FABRICATED, OFF-SITE AND MODULAR CONSTRUCTION METHODS**	Research suggests that industrialised construction processes can reduce waste by as much as 70-90%.[107]	Industrialised construction can offer a number of benefits, namely: enhanced quality control, reduced waste and risk of local environmental pollution, reduction in vehicle movements to construction sites, material efficiency, improved safety on construction sites and cost savings – though training and skills development are needed to harness these benefits.[94, 93] Increased efficiency is achieved through enabling construction activities to be undertaken simultaneously rather than sequentially, thereby reducing construction programmes. This offers gains for both developers (i.e. reduced cost) and the local community (i.e. reduced disturbance). For Mexico City specifically, industrialised construction could support efforts to rapidly deliver high quality, affordable housing, as has been achieved in other cities,[108] and connect to ongoing circular economy initiatives.	■ Missed opportunity cost for developers associated with longer construction programmes and the financial costs associated with this (e.g. of workforce, construction machinery). Quality of built structures remains highly susceptible to externalities, for example in weather. Similarly, it is assumed that industrialised construction techniques allows greater scrutiny of design quality and any remedial actions. Significant waste will be continued to be produced as a result of construction site activities.

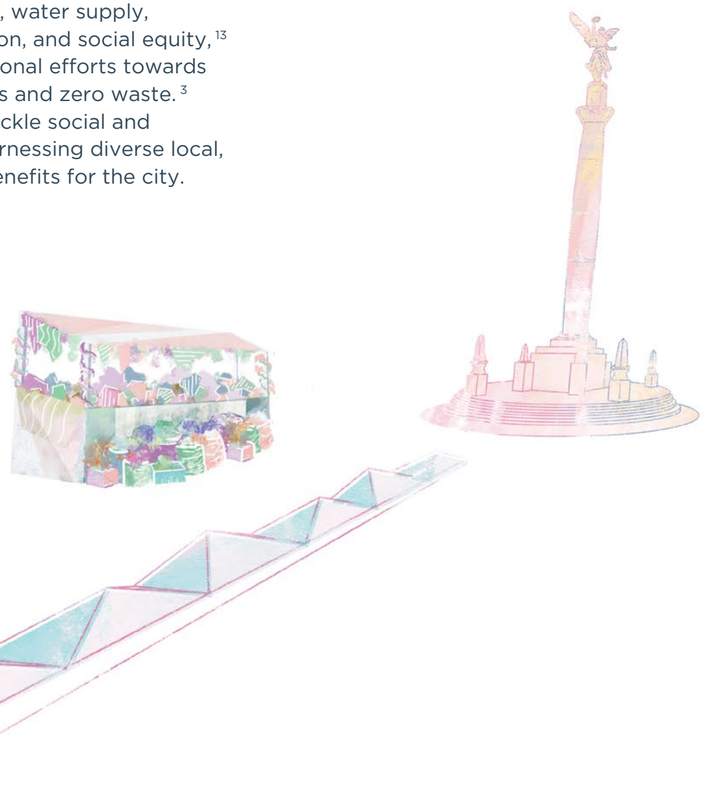
FIGURE 07 CONT.
Summary of emissions reductions and benefits of 'highly recommended' clean construction measures

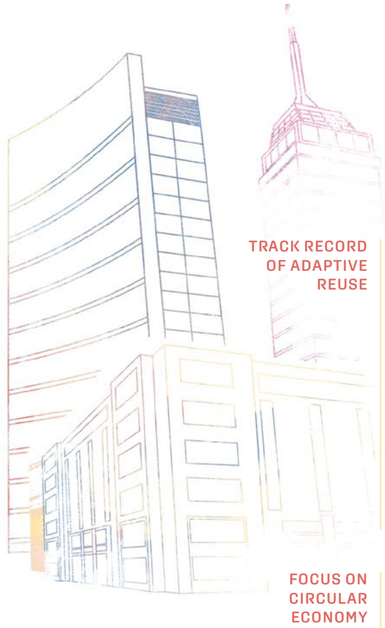
Priority clean construction measures.	Carbon emission reduction potential	Other benefits to Mexico City	Cost of inaction
Supporting and enabling actions			
 **BUILD PHYSICAL WASTE PROCESSING INFRASTRUCTURE: MATERIALS REUSE FACILITIES, RECYCLING CENTRES, LOCAL MATERIALS DISPOSAL ROUTES**	Waste processing infrastructure can avoid waste going to landfill or being dumped illegally. This can help provide short term opportunities for reusing building materials,[103] and connect to ongoing efforts by public authorities to stimulate circular economy processes. Reducing virgin steel use for example could potentially cut greenhouse gas emissions by 3% between 2017 and 2050.[103]	Interviewees cited that a lack of facilities and infrastructure to support material treatment, processing and use is a critical challenge for Mexico City. This action is essential to kick starting a local and regional economy for materials reuse. This in turn will create jobs for citizens, as will the construction of waste infrastructure and operating of these facilities. The impacts of poor waste management in Mexico City are well documented and include local watercourse pollution and increased flood severity.[63] This action will help address these issues through promoting better waste management across the construction sector.	■ Given the significant volume of construction waste generated and sent to landfill or dumped in Mexico City, not providing waste processing infrastructure will compromise the ambitions and targets contained within the Zero Waste strategy. Similarly, NADF-007 requires construction projects to use recycled and reused materials, waste infrastructure is critical to enabling this.
 **COLLECT AND SHARE DATA ON CLEAN CONSTRUCTION INITIATIVES AND LESSONS LEARNT**	Delivering carbon reductions requires joined up action across the construction sector. Interviewees highlighted that open dialogue and engagement between these actors is limited at present. In addition, interviewees acknowledged that the Mexico City construction industry is on a journey and requires greater knowledge and awareness of issues relating to clean construction in order to take meaningful action. Developing training, guidelines and tools will be critical to achieving this as well as the successful implementation of the other recommended measures.	Data monitoring will help close key information gaps and provide essential evidence to inform the development, implementation and refinement of clean construction measures. In addition, robust evidence will be vital to communicating the tangible, quantifiable benefits of clean construction measures for designers, contractors and developers. As Mexico City develops and begins to implement clean construction actions, forums built up through this action could be used to build a common understanding of and support for the ambitions of these measures.	■ A robust evidence base is crucial to informing the design, implementation and ultimately gaining approval for regulatory requirements related to clean construction. ■ Interviewees noted that there was relatively limited effort in preparing the city for the future in the Mexico City construction industry, and felt that clean construction measures could help with education and awareness raising linked to climate resilience and future planning.

FIGURE 07 CONT.
Summary of emissions reductions and benefits of 'highly recommended' clean construction measures

3 CONCLUSION

Construction in Mexico City is a significant part of both the formal and informal economy. It employs many thousands of people and delivers important, large-scale projects. Mexico City is grappling with challenges linked to air quality, water supply, housing standards and provision, and social equity,[13] but is also pioneering international efforts towards adaptive reuse of urban spaces and zero waste.[3] Clean construction can help tackle social and environmental issues, while harnessing diverse local, global, social and economic benefits for the city.





TRACK RECORD OF ADAPTIVE REUSE

FOCUS ON CIRCULAR ECONOMY

WHICH CLEAN CONSTRUCTION PROCESSES EXIST ALREADY IN MEXICO CITY?

Though the concepts of ‘clean construction’ and embodied carbon are not well established in Mexico City, the city already has a strong history of using clean construction techniques.

In terms of adapting existing buildings, the city has a legacy of refurbishing buildings in the wake of seismic events, an essential expertise for the protection and refurbishment of existing structures. Mexico City is also the home of pioneering examples of adaptive reuse like Cuitláhuac Park.[12] The city has been home to important flagship projects such as PILARES[73] and the Housing Improvement Program,[109] which have transformed and adapted existing spaces and provided vulnerable populations with the means to improve their homes. The city also has a strong track record of delivering energy efficiency improvements across the city.[7]

In terms of sustainability efforts, clean construction processes are emerging in Mexico City. Recent revisions to the NADF-007 are driving material reuse and recycling and similarly the latest revision of the SBCP priorities the use of lower impact construction materials. These build on requirements that have existed for a number of years but are only required in public projects. The Zero Waste strategy is driving the development of enabling infrastructure to support the development of this market, and new technical guidance is being produced to support uptake of such measures. The city is also working to tackle low levels of regulatory compliance, in collaboration with the districts.

WHICH ADDITIONAL CLEAN CONSTRUCTION MEASURES ARE BEST SUITED TO MEXICO CITY?

Mexico City has been tackling issues related to clean construction and greenhouse gas abatement in an integrated way. Prioritising actions that deliver outcomes for other key city priorities such as air quality, job creation and disaster response.

At present, limited regularity requirements exist to require or encourage clean construction activities. Equally, interviewees reported that understanding of clean construction is low. However, it is evident Mexico City's construction sector has a significant skills base to expand the implementation of a number of clean construction strategies across the city. Where policy does exist, compliance is low and enabling infrastructure is often lacking. This results in significant challenges, for example in collecting, sorting, reprocessing of construction and demolition waste to encourage circular reuse of materials and components. As such, a long-term transition to clean construction in Mexico City must involve the industry championing efforts to reduce rates of demolition, refurbish existing structures, mainstreaming the use of low carbon materials and increasing rates of disclosure, collaboration and regulatory compliance.

Through engaging with those involved in Mexico City's construction sector, this study has recommended seven clean construction measures. Given the wealth inequality across the city, these measures must be carefully designed to ensure that they are inclusive and enable those undertaking construction works in all parts of the city to understand, access and receive the benefits of clean construction.

Highly recommended measures for Mexico City	Why is it recommended for the city of Mexico City?
PROMOTE ALTERNATIVE USES FOR VACANT AND UNUSED STRUCTURES	Reports suggest that 10.8% of A and A+ commercial offices in Mexico City are vacant.[87] Interviewees highlighted this issue also, notably so in speculative developments, and that the issue has been deepened by the impacts of the COVID-19 pandemic. At the same time, Mexico City is facing significant housing challenges and often citizens have to travel two to four hours per day to their place of work.[5] Promoting alternative uses for vacant and underutilised structures is a powerful way to meet demands for housing and other functions, without the need for new build. This should be informed by monitoring vacancy rates across the city, engagement with citizens and the private sector and informed by equity assessments.
ADAPT AND REFURBISH STRUCTURALLY SOUND BUILDINGS RATHER THAN DEMOLISH	Mexico City is the most expensive place to buy residential property in Mexico.[31] Yet, 28.4% of the population lives in poverty.[13] Interviewees reported it is often preferred to demolish existing structures and rebuild. This process in turn is likely to be a significant source of carbon emissions for Mexico City's construction industry. Relative to demolition and rebuild, refurbishment can have a lower overall lifetime cost, cause less disruption to communities and better retain their identity.[92] In addition, studies have shown the whole life carbon associated with refurbishment is typically lower than that of demolition, rebuild and housing residents in modern, low energy demand homes.[104]
ESTABLISH REGULAR MAINTENANCE PROGRAMMES TO REPAIR AND RETROFIT EXISTING BUILDINGS	Interviewees reported that a culture of preventative maintenance is not well established in Mexico City. Consequently, buildings become dilapidated over time which in turn fuels a cycle of demolition and rebuild. Introducing a programme of regular preventative maintenance will help break this cycle and as such tackle associated greenhouse gas emissions, material use and waste generation. This action can also support the creation of green jobs across Mexico City and support healthier, safer and more productive environments for building occupants.[86]

Highly recommended measures for Mexico City	Why is it recommended for the city of Mexico City?
USE BIO-BASED MATERIALS AND CERTIFIED TIMBER PRODUCTS	Interviewees reported that a culture of 'permanence' and focus on minimising capital costs, mean that concrete, brick and steel are the primary building materials used in Mexico City. These materials have some of the highest embodied impacts, as such encouraging the use of low carbon alternatives could deliver significant reductions in greenhouse gas emissions for Mexico City's construction sector. For example, using timber as an alternative and reducing the use of cement could both deliver 6% reductions in greenhouse gas emissions between 2017 and 2050.[103] A range of traditional construction methods offer low carbon alternatives, but these have not been scaled. Similarly, though timber is abundant regionally the sources of this are not sustainably managed. Regulation such as NADF-007 will create a larger market for reused and recycled materials, but this relies on strict enforcement and enabling infrastructure.
USE PRE-FABRICATED, OFF-SITE AND MODULAR CONSTRUCTION METHODS	Nationally, 1,152 deaths due to occupational risks were reported.[47] Construction sites are dangerous working environments and likely a number of these deaths were attributable to construction. Construction sites also generate significant volumes of waste, risk pollution that compromises local environments and the health of residents. Industrialised construction offers an opportunity to tackle issues related to waste, pollution, community impacts in Mexico City, as well as reducing costs and improving the quality of construction. This is viewed as a significant opportunity for Mexico City for these reasons, but also in the potential for the rapid creation of affordable homes in response to housing needs.
BUILD PHYSICAL WASTE PROCESSING INFRASTRUCTURE, INCLUDING MATERIAL REUSE FACILITIES, RECYCLING CENTRES AND LOCAL MATERIALS DISPOSAL ROUTES	As evidenced by the Zero Waste strategy, the municipal government has high ambitions in relation to minimising waste production and the transition to circular use of materials. This is further supported by increasingly ambitions regulatory requirements such as NADF-007. The city is planning the expansion of waste management infrastructure across the city, this recommendation aims to support these plans. This enabling infrastructure is crucial to facilitating the future development of the market for reused and recycled materials across Mexico City.
COLLECT AND SHARE DATA ON CLEAN CONSTRUCTION INITIATIVES AND LESSONS LEARNT	Interviewees noted that the low uptake of clean construction measures for many in the construction sector is in part due to a lack of understanding. Developing an evidence of robust information and disseminating this widely across the sector will be vital in encouraging action. Similarly, the collection and continuous monitoring of data will be vital for the municipal government in promoting, regulating and implementing clean construction measures across the city.

HOW MIGHT THESE CLEAN CONSTRUCTION MEASURES BE IMPLEMENTED IN MEXICO CITY?

Shifting to these clean construction measures will involve major changes to the city's construction industry. This will not be achievable instantaneously and without wide engagement, representative of the diverse needs of the city's citizens. So ongoing research, stakeholder engagement and policy transitions will need to be planned carefully, with alignment to national and international sustainability efforts and funding.

HARD IMPLEMENTATION POWERS

The Mexico City municipal government has regulatory powers for its construction industry through building regulations, technical guidance, permit control and planning requirements. Though voluntary, the city is also responsible for the Sustainable Building Certification Programme. These can be updated to absorb clean construction principles, technical guidance for bio-based and sustainable materials and design techniques, and to disincentivise unnecessary demolition. Enforcement of these regulations remains a challenge in Mexico City and as such there is a need to build capacity to ensure these actions are effective and widely adopted. Cost has been cited as a key barrier to the adoption of many clean construction measures, as such regulatory powers can be combined with financial incentives to encourage action. For example, tax breaks and credits for manufacturers of lower carbon materials.

MUNICIPAL ASSETS

The municipal government has a high degree of control over assets and services owned by the city, with specific laws for public procurement and a list of 'green products' for use in public projects. Plans exist already for the construction of new waste processing centres, and to safeguard the city's water supply. Significant investments in infrastructure have been announced for sites across the city.[44] Within these plans the city could pilot the development of 'hubs' for industrialised construction and material reuse. The municipal government should lead by example through integrating clean construction principles into the management of the public building stock and procurement of public projects.

SOFT IMPLEMENTATION POWERS

The municipal government has relatively high flexibility to use non-legislative powers like pilot projects and influencing national level policy through working groups. Uptake of clean construction measures could be further supported through collaboration with others across the construction sector to build knowledge, awareness and understanding of clean construction measures and the benefits of these. The city is participating in a number of international forums, with other cities whose agenda on issues such as embodied carbon is more established. The municipal government could use these networks to further understand key opportunities and barriers other cities experienced in the implementation of such actions.

THE BENEFITS OF CLEAN CONSTRUCTION MEASURES IN MEXICO CITY

According to our engagement with members of Mexico City's built environment sector, key priorities for the city extend beyond carbon emissions, including water and air quality, affordable, high-quality and accessible housing, and green jobs and skills (Figure 05). Clean construction can support improvements in all of these areas:

How does clean construction support Mexico City's citizens to thrive?

- Minimises disruption and health impacts, for both workers and local communities, associated with construction activities through prioritising retrofit, refurbishment and industrialised construction which can reduce construction programmes.
- Minimises traffic congestion, tackling poor air quality and increasing road safety by reducing construction vehicle trips through low carbon alternatives such as timber and industrialised construction.
- Optimises building performance through maintenance and retrofit, in turn reducing operational costs, tackling fuel poverty, and creating healthier and more productive indoor environments.
- Stimulates green jobs in the city in areas where significant expertise exists through promoting city wide programmes of retrofit, refurbishment and maintenance.

How does clean construction support Mexico City's environment to thrive?

- Supports better waste management practices across the city as well as reducing associated greenhouse gas emissions of traditional disposal methods across Mexico City.
- Supports greenhouse gas emission and waste reductions through undertaking fabrication in controlled environments. This will also reduce risk of pollution to local ecosystems through increased quality assurance and reducing the duration of construction site activities.
- Supports reductions in greenhouse gas emissions where timber is selected in place of concrete, thanks to a reduction in vehicle trips.
- Reduces the demand for new build through adaptive reuse, refurbishment and retrofit, minimising urban sprawl, and protecting the water forest.

How does clean construction action in Mexico City support communities world-wide to thrive?

- Reduces the demand for materials, by promoting adaptive reuse, refurbishment and encouraging the use of recycled and reused content. This combats issues of resource scarcity and pollution in communities across the globe working or living next to mining or extraction zones.
- Delivers green jobs, expands the quality and scope of existing jobs and builds skills across the construction supply chain, supporting new industries for low carbon construction materials and waste processing.

How does clean construction action in Mexico City support efforts to improve the health of the whole planet?

- Reduces demand for construction materials with high embodied impacts, supporting global greenhouse gas emission reductions as well as reducing ecological risk across the supply chain.
- Contributes to sustainable production methods and ecosystem restoration across the supply chain through efforts to ensure sustainability of supply of timber, and bio-based materials like adobe construction.
- Reduces virgin material demand, through optimising the use of existing buildings and shifting to low carbon or reused materials. This could reduce consumption-based emissions in the global building and infrastructure sector by around 44% (by 2030 against a 2020 baseline). [103]

HOW CAN BARRIERS TO CLEAN CONSTRUCTION BE OVERCOME IN MEXICO CITY?

Mexico City has a strong foundation on which to build clean construction efforts. However, in our multi-stakeholder interviews, building and construction sector experts in Mexico City highlighted a variety of constraints, opportunities and considerations relating to integrating clean construction policy in the city. As such, there are some key considerations and approaches that the municipal government may wish to pursue in implementing and championing clean construction:

- **EMBRACE THE OPPORTUNITY CLEAN CONSTRUCTION OFFERS TO BUILD A MORE INCLUSIVE, EQUITABLE AND RESILIENT COMMUNITY AND CONSTRUCTION WORKFORCE ACROSS MEXICO CITY:** Rigorously use equity assessments, citizen engagement and data analysis to ensure proposed clean construction measures are inclusive, equitable and build community resilience. In turn, making the case for bolder and ambitious action.

- **BUILD CAPACITY WITHIN THE MUNICIPAL GOVERNMENT AND ACROSS THE DISTRICTS TO ACHIEVE GREATER REGULATORY COMPLIANCE:** Through collaboration with districts and aligned with efforts to build knowledge, invest in building Mexico City's capacity across the regulatory bodies to ensure legislative requirements can be more effectively managed and implemented, across all development in the city.

- **DEVELOP SPECIFIC REGULATIONS AND INCENTIVES FOR SMALL CONSTRUCTION PROJECTS AND SELF-BUILDING:** Work with all tiers of the construction sector to inform clean construction measures that recognise and support the diversity of construction activities across Mexico City.

- **LEVERAGE THE WEALTH OF EXISTING EXPERTISE AND INITIATIVES THAT ALIGN WITH CLEAN CONSTRUCTION PRINCIPLES:** Celebrate and share widely the successes of existing activities that support the principles of clean construction, to raise awareness, inspire action and drive sector and political support for further ambitious action across Mexico City.

- **DRIVE A NEW MINDSET FOR CONSTRUCTION BY RAISING AWARENESS OF CLEAN CONSTRUCTION DESIGNS, MATERIALS AND PROCESSES, DEBUNKING ANY FALSE PERCEPTIONS AND EMPHASISING THE BENEFITS:** Embed clean construction measures in public projects and procurement to lead by example. Partner with others across the construction sector, as well as the international forums Mexico City participates in, to raise awareness of not only what clean construction measures are but why they are needed and how they can contribute to wider benefits across the city and for citizens quality of life.

- **CONSULT AND ENGAGE WITH INDUSTRY STAKEHOLDERS TO SHAPE CLEAN CONSTRUCTION POLICIES:** Engage widely and deeply to shape effective policies and approaches to clean construction and build early engagement and support for these to ensure successful implementation.

MAIN TAKEAWAYS FOR OTHER REGIONS AND CITIES

INSPIRING WIDER ACTION

The clean construction measures and associated implementation mechanisms recommended for Mexico City are based on a specific analysis of the structure of the industry, regional concerns voiced by interviewees and the city's priorities and local implementation powers. However, many of these findings and recommendations are broadly transferable to other cities.

MEXICO CITY'S CHARACTERISTICS

Mexico City is a large city with extensive areas of informal building, low rates of regulatory compliance and engagement with technical standards, and a great deal of small firms and contractors. Cities sharing these characteristics may benefit from programmes of guidance, training and financial incentives for new clean construction measures, since adding these to building standards may not be effective alone. Similarly, stressing the broad benefits that can be achieved by pursuing clean construction will support in making the case for new approaches and policies.

BUILD ON EXISTING KNOWLEDGE

However, many cities will also face environmental challenges to their buildings, such as rebuilding after seismic activity, and a great deal of informal building where people use local resources like timber, cork, and reclaimed materials. Both of these areas are a strong footing for clean construction, which promotes building refurbishment and the use of alternative materials. As such, leveraging and mainstreaming these activities will help promote clean construction – though efforts will be needed to ensure that safe design practices are followed, and materials are sourced sustainably.

LEVERAGE EXISTING PROGRAMMES

Finally, cities may face challenges related to waste management and recycling that are a barrier to the circular use of materials in the sector. The municipal government has initiated many programmes to tackle such issues that may be a useful reference for other cities. These have included a combination of technical guidance and standards, creation of physical recycling and waste treatment infrastructure and local's skills development, supported by international organisations like the Ellen MacArthur Foundation and C40 Cities.

ENGAGEMENT AND COLLABORATION

The interviews and surveys that underpin this research have been informed by eight different city departments and initiated cross-sectoral industry engagement in Mexico City: early dialogue and consultation, both internally and externally, is critical in raising awareness and educating on the new topic that clean construction is. This collaborative process supports the city in drawing trends and challenges from the sector and understanding which measures to build on, and which to pay more attention to going forward.

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